Maryland Life Sciences Strategic Plan: The Current Competitive Position of Maryland

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Introduction

The establishment and successful development of a state bioscience cluster depend upon a number of key factors and drivers. A robust bioscience cluster requires a highly skilled and talented workforce, a strong local base of academic research, available and varied sources of capital, support from local and state governments, and private-sector companies with a stake in the region. This report by Battelle gauges Maryland's current position in the biosciences with respect to these fundamental factors and compares it with other elite bioscience states. This assessment of Maryland's competitive position across a variety of bioscience-related metrics will inform policymakers and other stakeholders on the competitive strengths, weaknesses, and emerging opportunities within the sector to guide strategic planning of state and local efforts into the future.

Both the assessment of Maryland's competitive position in the biosciences and a separate analysis by Battelle of core competencies of the Maryland bioscience sector accompany and support the Maryland Life Sciences Advisory Board strategic plan, ***BioMaryland 2020: A Roadmap for Bioscience Development***.. In this competitive assessment, Maryland's current position in the biosciences is compared with a set of its peers in the biosciences (California, Massachusetts, New Jersey, North Carolina, and Pennsylvania) and assessed across a varied set of key bioscience performance metrics:

- Bioscience industry employment
- Bioscience research and development (R&D) expenditures (university, industry, and federal)
- Venture capital investments in the biosciences
- Bioscience-related patents
- Workforce development in the biosciences
- Technology transfer and commercialization.

On the high-level fundamentals, Maryland's bioscience sector shows positive performance:

- **Overall bioscience industry employment in Maryland is growing robustly**, rising 14.5 percent from 2001 to 2006, adding more than 3,200 jobs, to reach well over 25,000 jobs. By comparison, the national sector grew only 5.7 percent; and Maryland outpaced key competitors such as California, Massachusetts, Pennsylvania, and New Jersey. Only North Carolina among the bioscience elite, with growth of 18.5 percent, outpaced Maryland's bioscience industry growth as measured in jobs created.
- **University bioscience research grew substantially**. From 2002 to 2007, Maryland's academic bioscience research base grew by 44 percent, from $878 million to $1.3 billion. Maryland outpaced national university R&D growth in the biosciences, which grew by 42 percent during the same period.
- **Maryland remains a talent magnet in the biosciences**. Maryland has one of the most significant concentrations of highly trained bioscience research scientists in the world. This rich

talent base is one of Maryland's major assets in the biosciences—and remains an anchor for future bioscience development.

Despite this evidence of sound performance, the most striking aspect of Maryland's current position is the still untapped potential of its bioscience research base. While Maryland remains one of the leading centers for bioscience research—with sizable and high-quality university research efforts and the nation's largest concentration of federal laboratory bioscience research funding—its overall bioscience industry development still does not measure up to this base of research activity.

Even with the continuing bioscience industry gains, Maryland is still less developed and concentrated in its bioscience industry base than its leading competitors. One specific measure of industry development is the concentration of that industry's employment within a state economy compared with the nation. Those states that are highly developed in a particular industry will have a greater concentration of employment in an industry relative to the nation and are therefore considered to be "specialized" in that industry. At the state level, a 20 percent higher concentration in an industry is the standard requirement for designating an industry concentration as specialized. The leading bioscience competitors—California, Massachusetts, New Jersey, North Carolina, and Pennsylvania—all have at least a 30 percent greater concentration than the nation in the biosciences. **Maryland's level of concentration is only 7 percent higher than the national average, and so it cannot yet be regarded as specialized in the bioscience industry from an overall perspective.**

Maryland's greatest success in bioscience industry development is found within its highly focused base of bioscience R&D firms, a sector in which Maryland stands out as a national leader. With nearly 13,000 jobs, bioscience R&D firms account for half of Maryland's overall bioscience industry employment and accounted for 69 percent of its total growth in bioscience jobs between 2001 and 2006. **Maryland is clearly a national star in private-sector bioscience R&D, with an employment concentration twice the national average.**

Among leading bioscience states, only Massachusetts is more specialized than Maryland in its bioscience R&D industry. But, unlike Massachusetts, which also has a large and specialized medical device sector, Maryland's only other specialized bioscience industries are the more niche and smaller industries of *in vitro* diagnostics, with 2,400 jobs, and biological processing, with 1,527 jobs.

Looking to the future, the bioscience R&D industry is the pipeline for innovative bioscience companies. While many of these bioscience R&D companies are providing research services to federal labs, universities, and other bioscience companies, a significant number of Maryland's bioscience R&D companies are involved in developing new products, but have not yet been able to complete product development or win regulatory approval to bring their products to market. As these product-oriented bioscience R&D companies succeed, they will enter more established product-oriented industries, such as therapeutics, diagnostics, and bioscience equipment.

Many of these product-focused bioscience R&D companies are present in Maryland to be close to the state's research complex, because they are seeking to commercialize discoveries made at Maryland's research institutions, collaborate with these research institutions, or tap them for key talent. In fact, among the states, Maryland receives the highest level of R&D funding to industry from the federal government; these federal funds to industry for research are by far the largest source of funding for industry research activities in Maryland.

The challenge for Maryland in developing its bioscience industry is to foster an environment that can assist these product-oriented bioscience R&D companies to succeed in their product development efforts and win regulatory approval to bring their products to market. In the years ahead, Maryland needs to work harder and smarter to accelerate the rate at which its research strengths translate into viable bioscience companies that seek to bring products to market. Activities such as access to early-stage capital, ongoing product development support, precommercialization services, and clinical research resources are essential for Maryland's numerous product-oriented bioscience R&D companies to enter bioscience product markets and industries.

As these product-oriented bioscience firms advance, they also generate opportunities for Maryland to attract leading global bioscience companies. A commonplace occurrence in bioscience industry development is the acquisition of emerging product-oriented bioscience R&D companies by larger bioscience businesses. To the extent that emerging Maryland bioscience companies can offer a new line of business or a well-developed footprint to the acquiring global bioscience company, there is an excellent chance for these global bioscience companies to grow and expand their presence in Maryland even if they do not relocate their companies. Among the most notable global companies to enter Maryland recently are AstraZeneca through the acquisition of MedImmune, Teva through the acquisition of CoGenesys, and Qiagen's expanded presence through the acquisition of Digene. So, an excellent business development strategy to attract global bioscience players to Maryland and have them expand in-state is to encourage the creation and development of more robust emerging bioscience companies that create more developed footprints beyond R&D, with validated product opportunities and unique facilities and capabilities for product development, production, and customer outreach and service.

Still, the road ahead for Maryland will not be easy, and the following are clear warning signs:

- **Bioscience venture-capital investment in Maryland has fallen off sharply for two consecutive years**, running contrary to bioscience venture-capital investment trends in the nation and its peer states. A closer examination reveals that significant venture-capital funds are under management in Maryland, but they are not investing in Maryland-based companies.
- **The nation's ability to fund bioscience research is falling off.** After doubling over a period of 5 years, the National Institutes of Health's (NIH's) budget is once again failing to keep up with inflation, and the prospects in the next few years do not seem bright. On a single year-to-year change, Maryland universities actually realized a decline in research funding from 2006 to 2007, after recent years of strong growth. This recent decline requires close attention.
- **The climate for innovation and industry partnerships with federal labs, particularly NIH, has cooled because of recent concerns about conflict of interest.** Perhaps reacting to perception rather than fact, stakeholders are nonetheless concerned that it will continue to be more difficult for industry to engage with NIH researchers to advance translation and commercialization of NIH discoveries.

The following quantitative analysis illuminates these broad findings and the competitive position of Maryland in the biosciences.

Bioscience Industry Position

The biosciences as an industry maintain a unique set of characteristics. They represent a varied set of companies that span manufacturing, services, and research activities; a highly skilled workforce; and a whole range of products and services classified among nearly 30 individual industries. Much more than other sectors, the biosciences are dynamic and evolve with the latest research and scientific discoveries with tremendous widespread impact on medicine, food, and alternative fuels. The common link among this diverse set of firms is an application of knowledge of how living organisms function.

As an industry, the biosciences in Maryland are emerging. Though the state is not considered to be specialized in the overall bioscience industry, it has a highly ranked and specialized concentration in the bioscience R&D sector that reflects its world-class biomedical complex—with an employment concentration in private-sector bioscience R&D twice the national average. Maryland's overall emergence in the biosciences has also been driven by recent strong growth in subsectors that are less concentrated in Maryland, including therapeutics and diagnostics. Though these represent emerging niches, their growth signals a shift toward a more diversified Maryland industry base in the biosciences.

This section includes an employment analysis of the bioscience industry base in Maryland, including its current position relative to a set of comparison states, as well as recent trends. The analysis also includes national comparisons to provide context for Maryland's relative performance. Labor market data in this analysis are for 2006, the most current annual data available. Industry trends are examined over the 6 years from 2001 through 2006.

Defining the Bioscience Industry

The changing and diverse nature of the biosciences makes the industry difficult to define. The federal statistical system does not identify one complete bioscience industry classification. To encompass the range of relevant bioscience activity in the United States, many detailed industries must be combined. Battelle has assisted many states and local areas throughout the United States in identifying and developing their bioscience industry base. After years of research and fieldwork, Battelle has identified four major subsectors that engage in core bioscience activity—agricultural feedstock and chemicals; drugs and pharmaceuticals; medical devices and equipment; and research, testing, and medical laboratories. These subsectors and their definitions have been adopted by the Biotechnology Industry Organization (BIO) in the biennial Battelle/BIO national bioscience sector reports. [1] The four major subsectors are described below.

- **Agricultural Feedstock and Chemicals**. This subsector applies knowledge of the biosciences and biotechnologies to the processing of agricultural goods and production of organic and agricultural chemicals. The subsector includes the emerging activity around the production of biofuels. Product examples include ethanol, fertilizers, pesticides, sustainable lubricants and oils, and food and feed additives.
- **Drugs and Pharmaceuticals**. This subsector produces commercially available medicinal and diagnostic substances. Firms may be large and multinational and are heavily engaged in R&D activities to bring drugs to market. Product examples include vaccines; oncology, neurology, and cardiology treatments; tissue and cell culture media; herbal supplements; and diagnostic substances.
- **Medical Devices and Equipment**. Firms in this subsector produce biomedical instruments and other health care products and supplies for diagnostics, surgery, patient care, and laboratories. The subsector has integrated advanced electronics and information technologies to improve and automate testing and patient care capabilities. Product examples include bioimaging equipment; orthopedic and prosthetic implants and devices; walkers, wheelchairs, and beds; dental instruments and orthodontics; laser eye surgery equipment; defibrillators (automated external defibrillators or AEDs); and stents and other implantable devices.
- **Research, Testing, and Medical Laboratories**. This subsector includes a range of activities, from highly research-oriented companies developing and commercializing new drug discovery/delivery systems, to more service-oriented medical or other testing firms. Product examples include functional genomics and drug discovery techniques, diagnostic testing,

[1] The 2008 Battelle-BIO report, "*Technology, Talent, and Capital: State Bioscience Initiatives 2008*," is available at http://bio.org/local/battelle2008/.

preclinical and clinical drug development, biomarkers, nanoscale drug delivery systems, and research models and laboratory support services.

An important element of the bioscience industry, the research conducted at academic health centers, research hospitals, and other research-driven institutions might be considered a fifth bioscience subsector; but, unfortunately, this hospital component cannot be isolated. Ideally, one would sort out and include those research centers to identify only the bioscience R&D that occurred within those establishments. However, no reliable ways exist for isolating these components from the three existing hospital industries in the North American Industry Classification System (NAICS) that are dominated by health services. Limited analysis on the overall hospital sector in Maryland—separate from the bioscience sector—is included in this report because it is important and relevant; but, this data issue and data limitations must be acknowledged.

The NAICS is the official federal government system for classifying establishments and their activities into the appropriate sectors. NAICS industries at the most detailed (six-digit) level were selected for this analysis and together make up the major sectors and subsectors. Using this system, 27 industries at the six-digit level of detail were chosen. These detailed industries were aggregated up to the four major subsectors of the bioscience industry. Table 1 shows a full list of bioscience NAICS codes.

Table 1. The bioscience subsector industries and NAICS codes

NAICS Code	Industry Description
Agricultural Feedstock & Chemicals	
311221	Wet corn milling
311222	Soybean processing
311223	Other oilseed processing
325193	Ethyl alcohol manufacturing
325199	All other basic organic chemical mfg.
325221	Cellulosic organic fiber manufacturing
325311	Nitrogenous fertilizer manufacturing
325312	Phosphatic fertilizer manufacturing
325314	Fertilizer, mixing only, manufacturing
325320	Pesticide and other ag. chemical mfg.
Drugs & Pharmaceuticals	
325411	Medicinal and botanical manufacturing
325412	Pharmaceutical preparation manufacturing
325413	In-vitro diagnostic substance manufacturing
325414	Biological product (except diagnostic) mfg.
Medical Devices & Equipment	
334510	Electromedical apparatus manufacturing
334516	Analytical laboratory instrument mfg.
334517	Irradiation apparatus manufacturing
339111	Laboratory apparatus and furniture mfg.
339112	Surgical and medical instrument manufacturing
339113	Surgical appliance and supplies manufacturing
339114	Dental equipment and supplies manufacturing
339115	Ophthalmic goods manufacturing
339116	Dental laboratories
Research, Testing, & Medical Laboratories	
541380*	Testing laboratories
541710*	Physical, engineering and biological research
621511	Medical laboratories
621512	Diagnostic imaging centers

*Includes only the portion of these industries engaged in biosciences activities.

Two of the six-digit NAICS codes in Table 1—testing laboratories (NAICS 541380) and physical, engineering, and biological research (NAICS 541710)—were adjusted in this analysis to include only the share of these industries directly engaged in activities in biology or other life sciences in Maryland. To isolate these relevant bioscience components, Battelle used information and data from the U.S. Census Bureau's Economic Census.

Given the dynamic nature of the biosciences, one must also acknowledge t that certain economic activities may not be captured in this definition according to NAICS codes. Aggregating production activities on a broad scale will inevitably result in some data gaps; however, characterizing this industry according to the most detailed NAICS data available is the best approach to analyzing the majority of key bioscience economic activity in the United States and Maryland. Finally, the database used for employment analysis relies on employers to classify themselves for records kept under each state's unemployment insurance program. The data depend on both an employer and the state for quality control measures; and at times, employers and government record-keepers may inappropriately classify themselves. The Data and Methodology Appendix contains detailed information on the data and methodology used in this employment analysis.

The Biosciences in Maryland

Maryland has a sizable, concentrated, and rapidly growing industry employment base in the biosciences. Sector firms in Maryland operate more than 1,000 individual business establishments employing 25,453 in 2006 (Table 2). Both bioscience establishments and employment experienced double-digit increases between 2001 and 2006, rising by 16.1 percent and 14.5 percent, respectively. The state's recent strong increase in bioscience jobs compares favorably with the rest of the Maryland private sector, which grew by 4.8 percent during this same period.

Employment concentration gauges a state's or region's degree of specialization in a given industry or cluster of industries. Location quotients (LQs) measure the degree of job concentration within a region relative to the nation.[2] A state LQ greater than 1.0 indicates a greater concentration

Table 2. Maryland and U.S. bioscience employment metrics, 2001–2006

Industry Subsector	2006 Establishments	Percent Change Estab, '01-06	2006 Employment	Percent Change Empl, '01-06	2006 Location Quotient
Maryland					
Total Biosciences	**1,028**	**16.1%**	**25,453**	**14.5%**	**1.07**
Agricultural Feedstock & Chemicals	19	-10.2%	381	-34.6%	0.20
Drugs & Pharmaceuticals	62	-8.8%	5,536	15.3%	0.95
Medical Devices & Equipment	233	-7.7%	3,080	2.7%	0.40
Research, Testing, & Medical Labs	714	31.3%	16,457	18.9%	**2.00**
United States					
Total Biosciences	**42,910**	**15.7%**	**1,295,979**	**5.7%**	**N/A**
Agricultural Feedstock & Chemicals	2,183	3.8%	105,846	-6.1%	N/A
Drugs & Pharmaceuticals	2,654	1.9%	317,149	4.0%	N/A
Medical Devices & Equipment	15,215	0.3%	422,993	-0.9%	N/A
Research, Testing, & Medical Labs	22,857	32.7%	449,991	17.8%	N/A

Source: Battelle analysis of U.S. Bureau of Labor Statistics (BLS), Quarterly Census of Employment and Wages (QCEW) data from the Minnesota IMPLAN Group.

[2] Location quotients (LQs) are a standard measure of the concentration of a particular industry in a region relative to the nation. The LQ is the share of total state or regional employment in the particular industry divided by the share of total industry employment in the nation. An LQ greater than 1.0 for a particular industry indicates that the region has a greater relative concentration, whereas an LQ less than 1.0 signifies a relative underrepresentation. An LQ greater than 1.20 denotes employment concentration significantly above the national average. In this analysis, regional specializations are defined by LQs of 1.20 or greater.

than the national average. When the LQ is significantly above average, 1.20 or greater, the state has a *specialization* in the industry.

In 2006, Maryland's concentration of bioscience jobs was 7 percent greater than the national average concentration in bioscience jobs—so Maryland's LQ for the bioscience industry was 1.07, indicating a strong, but not yet specialized, overall concentration of bioscience jobs. At its current job-growth rate, however, Maryland is clearly on a path toward emerging as a state specialized in the bioscience sector.

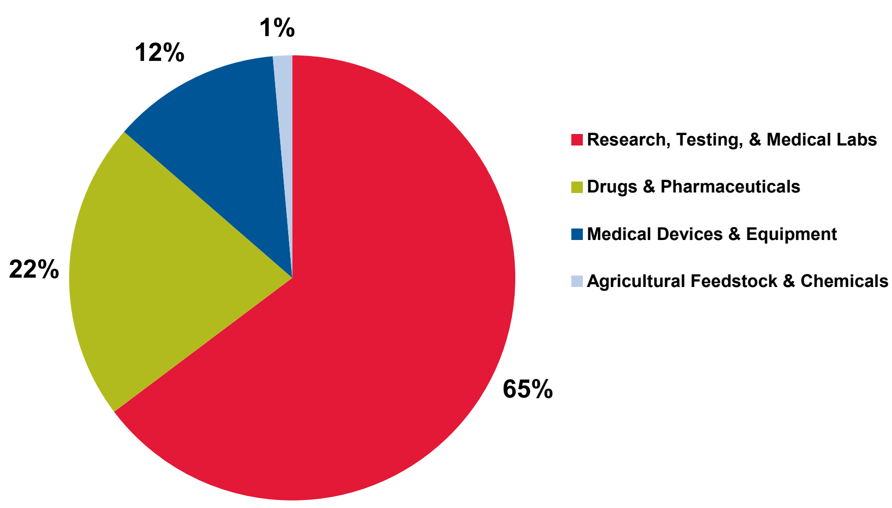
Major Bioscience Subsectors

To fully understand the underlying composition, niche strengths, and recent trends driving Maryland's bioscience industry, it is critical to examine the four major subsectors that combine to form the diverse and dynamic overall bioscience industry. Further, a separate but highly related component, hospitals, will also be examined to inform the state of broad biomedical strengths.

The nature and composition of a state's or region's bioscience sector can vary dramatically based upon regional strengths and economic characteristics such as the presence of local academic research institutions, the availability of venture capital dollars, the regional talent base, and historical industry strengths. Based upon these and other characteristics, clusters of interrelated entities can form niches within the regional biosciences that shed light upon what that Region does best and where emerging areas of opportunity lie.

In Maryland, the biosciences center around a large and highly specialized core of both public and private R&D activities in the biosciences (only private sector data are presented here). From an industry subsector perspective, these R&D activities are combined with the activities of medical labs and diagnostic imaging centers to form the "research, testing, and medical laboratories" subsector. ***This "research, testing, and medical laboratories" subsector accounts for two of every three Maryland bioscience jobs—and is led by Maryland's particularly high concentration in the bioscience R&D Industry*** (Figure 1). The "drugs and pharmaceuticals" subsector accounts for 22 percent of bioscience jobs in the state—a share that has remained steady since 2001 as the entire

Figure 1. Employment composition of the Maryland bioscience sector, 2006



sector has grown. The "medical devices and equipment" subsector accounts for 12 percent of bioscience jobs, and the "agricultural feedstock and chemicals" subsector makes up the remaining 1 percent.

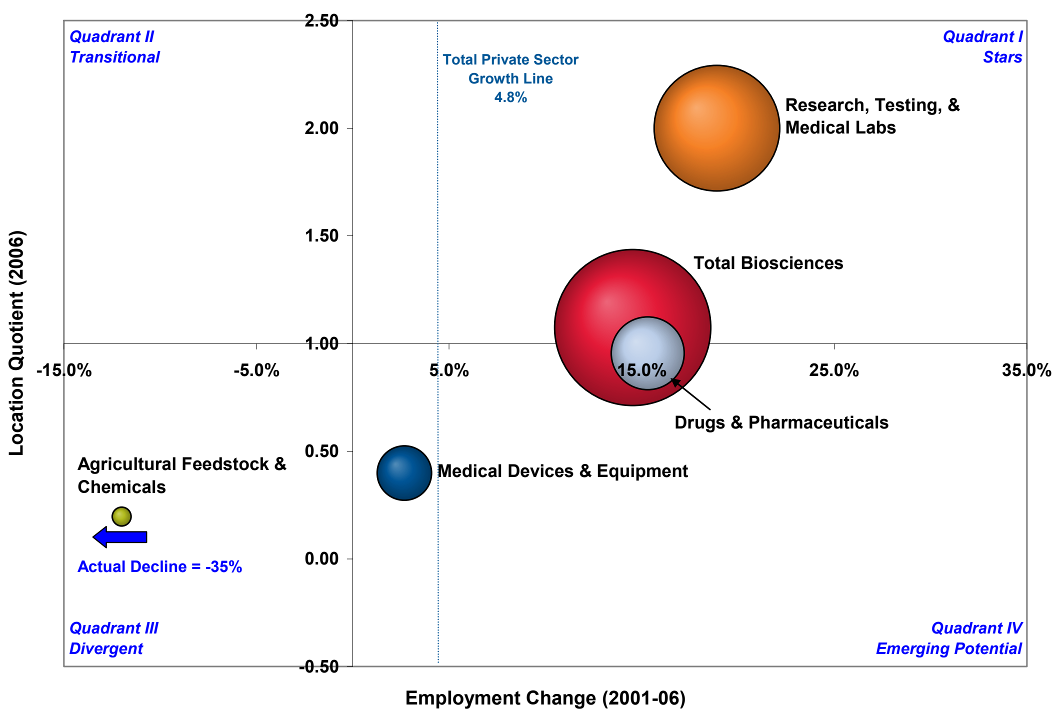
The red "Total Biosciences" bubble in Figure 2 shows the impressive overall growth of bioscience jobs in Maryland between 2001 and 2006—**three times the 4.8 percent growth observed in the overall Maryland private sector.** The Maryland bioscience LQ is 1.07 for 2006, reflecting a 7 percent higher level of concentration in bioscience jobs than the national average. This level positions Maryland overall as moving into Quadrant I (the "Stars" quadrant). Because the overall level of Maryland concentration in bioscience jobs remains below the 1.20 LQ threshold, Maryland is not yet regarded as specialized in the overall bioscience sector, although it is certainly seen as specialized in its bioscience R&D industry.

Figures 2 through 8 and Figures 10 and 17 are bubble charts providing a snapshot of three key employment variables that track recent performance:

- Employment size (size of bubble)
- Relative employment concentration (LQ)
- Recent employment growth (2001 to 2006 [2002 to 2007 for Figure 17]).

The quadrants in which the bubbles lie provide insight into relative performance of each industry subsector and allow for a general characterization based upon these variables.

Figure 2. Maryland bioscience subsectors, degree of specialization, employment growth, and size, 2006; the bioscience sector has experienced rapid growth in Maryland, led by bioscience R&D



Driving the bioscience sector's recent growth is the large, specialized, and growing research, testing, and medical labs subsector. State firms in the subsector operate 714 individual business establishments, a 31 percent increase between 2001 and 2006. These firms employ 16,457, with the majority performing the core bioscience R&D and laboratory work that drives much of the entire bioscience sector through breakthrough research developments and core innovation and design work.

Maryland has an LQ of 2.00—twice the national average concentration of jobs—in the research, testing, and medical labs subsector. This subsector grew by nearly 19 percent between 2001 and 2006 or just ahead of the national growth rate (up 18 percent during the same time period).

A further look into the research, testing, and medical labs subsector reveals that Maryland's success in bioscience industry development is found within its highly focused base of bioscience R&D firms, a sector in which Maryland stands out as a national leader. With nearly 13,000 jobs, this single industry of bioscience R&D represents half of Maryland's overall bioscience industry employment and accounted for 69 percent of the state's total growth in bioscience jobs between 2001 and 2006. While many of these bioscience R&D companies are providing research services to federal labs, universities, and other bioscience companies, a significant segment of Maryland's bioscience R&D companies are involved in developing new products, but have not yet been able to complete product development and win regulatory approval to bring them to market. As these product-oriented bioscience R&D companies succeed, they will enter more established product-oriented industries, such as diagnostics, therapeutics, and bioscience equipment.

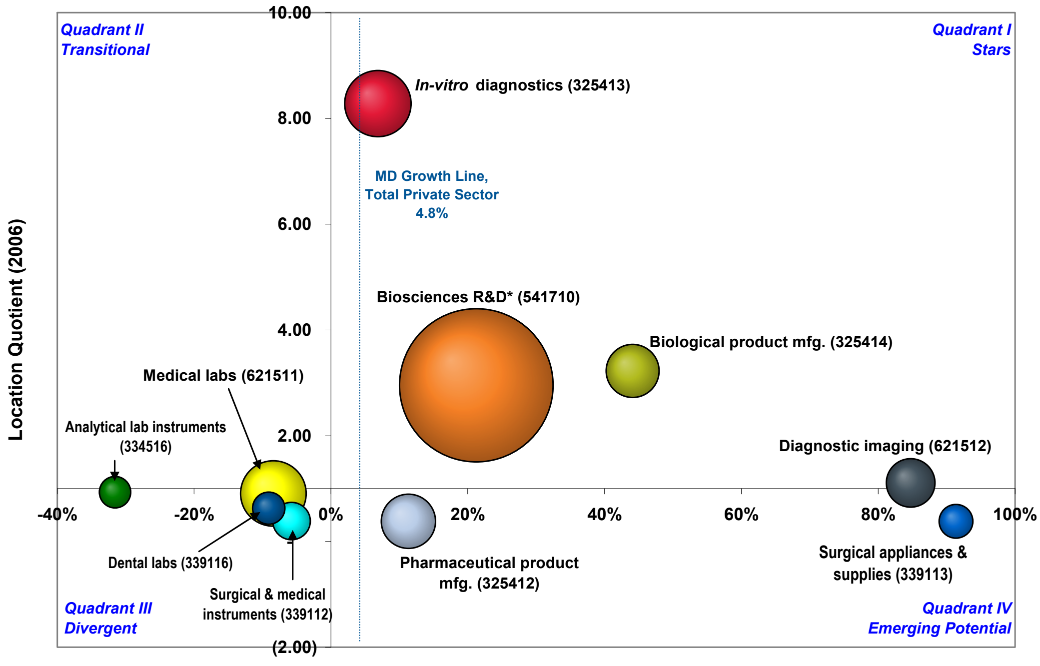
Though modest in size, Maryland drugs and pharmaceuticals firms have added jobs in recent years. With just over 5,500 jobs, Maryland's drugs and pharmaceuticals subsector has developed an emerging presence. The state added 735 jobs, on net, representing an increase of more than 15 percent between 2001 and 2006 in the subsector. This rate compares with a relatively slow-growth national subsector that increased jobs by 4 percent during this same time period. With an LQ of 0.95 in 2006, Maryland has not yet reached the national average concentration.

In medical devices and equipment, Maryland has a small but growing presence. Despite a slight decline at the national level between 2001 and 2006 (down 0.9 percent), Maryland medical devices and equipment firms grew their payrolls to 3,080, or by 2.7 percent, during this same period. The state is home to 233 businesses primarily engaged in manufacturing surgical and medical instruments and surgical appliances and supplies.

The agricultural feedstock and chemicals subsector has little employment in Maryland and lagged even the national subsector's employment declines between 2001 and 2006. In 2006, the subsector in Maryland employed almost 400 across just 19 establishments. The state's job total in this subsector decreased by about 200 jobs, or 35 percent, between 2001 and 2006.

Drivers of the four major subsectors are revealed by examining the detailed industry components of each subsector at the six-digit NAICS level. For Maryland, 10 industries had employment levels exceeding 500 in 2006. Figure 3 presents these 10 industries and provides a snapshot of the underlying bioscience industry drivers in Maryland.

Figure 3. Maryland's bioscience industries, degree of specialization, employment growth, and size, 2006; 10 of the state's bioscience industries had 500 or more employees in 2006, led by bioscience R&D



Note: NAICS code in parenthesis.

The 10 Maryland bioscience industries in Figure 3 are examined in greater detail in the following section, which analyzes each industry in comparison to the nation and benchmark states.

Maryland's Competitive Position in the Biosciences

The previous section presented an overview of Maryland's current employment and recent trends in the biosciences relative to the United States. In this section, Maryland is compared with a set of benchmark states—California, Massachusetts, New Jersey, North Carolina, and Pennsylvania—viewed as national peers in the biosciences. Bubble and other charts are used to compare these states relative to Maryland across each of the major bioscience subsectors and the hospitals subsector.

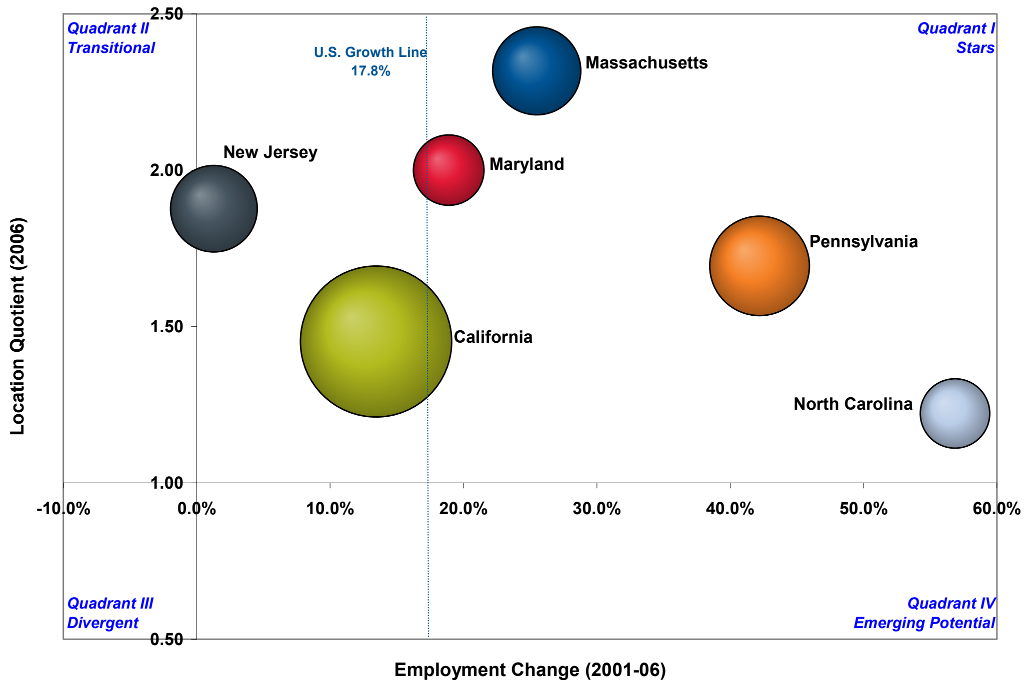
In the **research, testing, and medical laboratories subsector**, Figure 4 illustrates Maryland's high degree of employment specialization and recent strong growth compared with the nation. Other summary highlights and comparisons include the following:

Maryland and all five benchmark states are specialized in this subsector (each has a LQ greater than 1.20). In fact, Figure 4 represents 6 of only 15 states and Puerto Rico with a specialized LQ. In addition, each of these states ranks among the top 10 nationally in this subsector.

The research, testing, and medical laboratories subsector is clearly the high-growth subsector within the U.S. bioscience sector. It is the only subsector to experience double-digit job growth nationally between 2001 and 2006, increasing by 17.8 percent and driven largely by growth in Maryland and the benchmark states presented in this analysis. Pennsylvania and North Carolina led these states in growth, increasing by 42 percent and 57 percent, respectively. Employment in this subsector in Maryland increased by nearly 19 percent during the same time period.

But, Maryland stands out in the extent to which its research, testing, and medical labs subsector is concentrated primarily in the bioscience R&D Industry. Roughly 75 percent of Maryland's jobs in this subsector are in bioscience R&D, while nationally the bioscience R&D share of the subsector is closer to 50 percent. Only Massachusetts (LQ of 2.32) among leading bioscience states is more specialized than Maryland (LQ of 2.0) in its bioscience R&D industry. But, unlike Massachusetts, which also has a large and specialized medical devices and equipment subsector, Maryland's only other specialized bioscience industries are the more niche and smaller industries of *in vitro* diagnostics, with 2,400 jobs, and biologicals manufacturing, with 1,527 jobs.

Figure 4. Research, testing, and medical labs subsector vs. benchmark states, 2006; Maryland is highly specialized and outpacing national job growth



In **drugs and pharmaceuticals**, Figure 5 exhibits Maryland's modest but emerging presence. Though the subsector has a modest job base in Maryland compared with several leading state producers of pharmaceuticals, strong state job growth between 2001 and 2006 has propelled the industry and contributed to overall bioscience growth. The subsector added more than 700 jobs between 2001 and 2006 (up 15.3 percent) and now employs 5,536 Maryland workers or one-fifth of the state bioscience workforce. Other summary highlights and comparisons include the following:

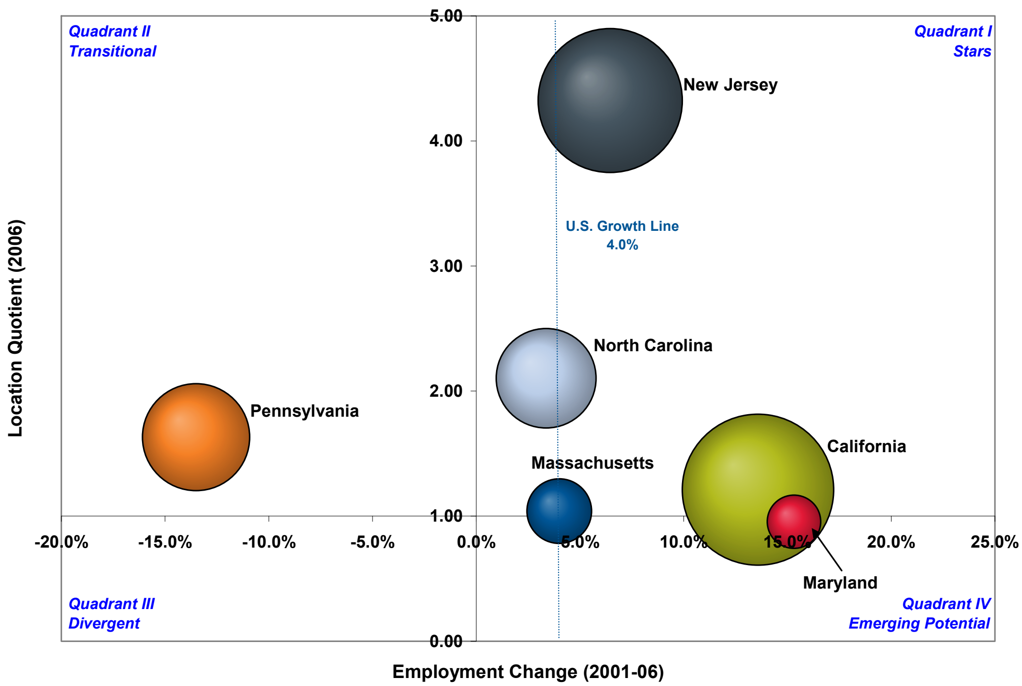
California and New Jersey rank first and second among all states in employment within the drugs and pharmaceuticals subsector, with 44,500 jobs and 40,400 jobs, respectively, in 2006. New Jersey is considered highly specialized in the drugs and pharmaceuticals subsector, with a 4.32 LQ in 2006 or more than four times the national average concentration. Maryland ranks 13th in the subsector, with 5,536 jobs in 2006.

Most large drug production operations in the United States are coded within the detailed industry component "pharmaceutical preparation manufacturing" (NAICS 325412). This is the case in the large producer states like New Jersey, California, and Pennsylvania where typically three-quarters of subsector jobs are found in this industry. **By contrast, in Maryland, the largest and most specialized industries are *in vitro* diagnostic substances (14 firms; 2,400 jobs; 8.28 LQ)**

and biological products manufacturing (9 firms; 1,527 jobs; 3.22 LQ).[3] This information demonstrates an interesting niche for Maryland within drugs and pharmaceuticals—a growing and highly specialized biological products industry.

A transition is occurring in drugs and pharmaceuticals reflected in the recent job declines in Pennsylvania. Subsector growth has slowed in recent years in the industry and, as data become available for 2007 and 2008, they may indicate more job declines. Despite this recent negative employment trend in the subsector, Maryland managed to increase its job base in drugs and pharmaceuticals by more than 700 between 2001 and 2006 (15.3 percent growth) and outpaced the larger state subsectors across the benchmark states.

Figure 5. Drugs and pharmaceuticals subsector, Maryland vs. benchmark states, 2006; a modest, but emerging subsector presence for Maryland



In **medical devices and equipment**, Figure 6 shows Maryland's limited employment but relative emergence. Other summary highlights and comparisons in the subsector include the following:

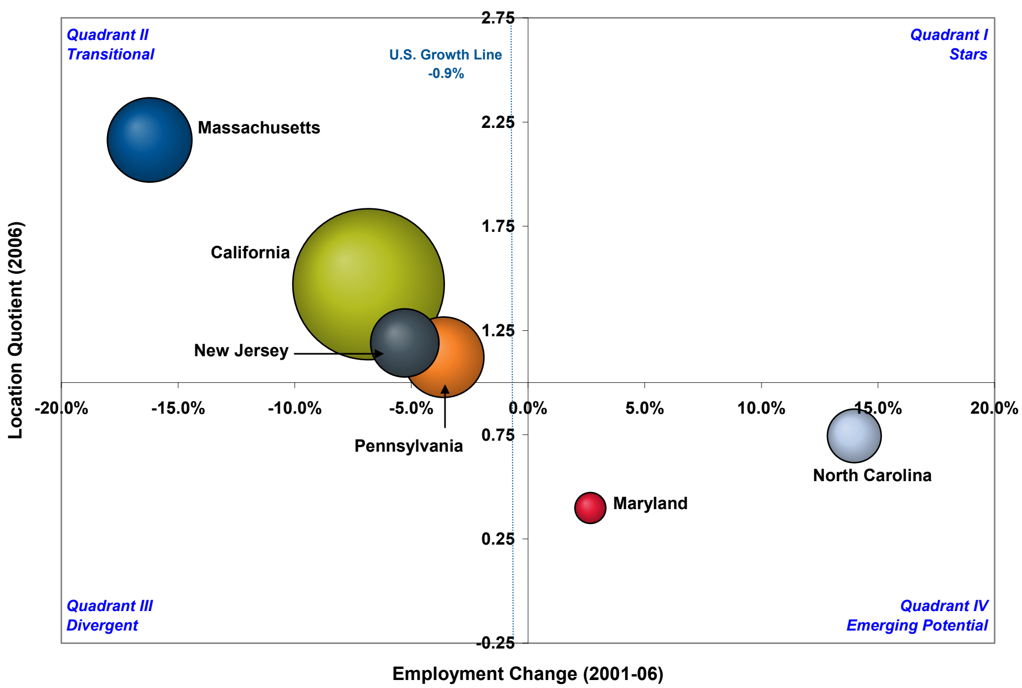
California is the leading national employer in the production of medical devices, with about 72,100 jobs in 2006 and a specialized LQ of 1.47. Among the other benchmark states, Massachusetts (22,500 jobs; 2.16 LQ) and Pennsylvania (20,500 jobs; 1.12 LQ) are the next largest. Each of these larger states in medical devices and equipment experienced recent job losses and contributed to a modest employment decline nationally between 2001 and 2006 (down 0.9 percent), although since 2004, the U.S. sector has rebounded and grown to some degree (up 2.8 percent). Maryland has a small but growing presence in the subsector—state medical device firms grew their payrolls to 3,080, representing an increase of 2.7 percent or 80 jobs, between 2001 and 2006. The state is home to 233 businesses primarily engaged in manufacturing surgical and medical instruments and surgical appliances and supplies.

[3] According to the official NAICS definition, "Biological product (except Diagnostic) manufacturing" includes firms primarily engaged in manufacturing vaccines, therapeutics, toxoids, blood fractions, and culture media of plant or animal origin.

The composition of regional medical devices and equipment subsectors can vary considerably. Nationally, almost half of subsector employment is within two broad device categories—surgical and medical instruments, and surgical appliance and supplies manufacturing. **Maryland's modest presence in medical devices and equipment manufacturing features no specialized industries and fewer than 1,000 jobs in its four largest components**—surgical and medical instruments, surgical appliance and supplies, dental labs, and analytical lab instruments.

In contrast to the slow-growth or no-growth states around the country, North Carolina has experienced rapid emergence in the production of medical devices. With an industry composition similar to the national subsector, North Carolina device firms have added jobs at a rapid pace despite job declines nationally.

Figure 6. Medical devices and equipment subsector, Maryland vs. benchmark states, 2006; a small subsector, but one that has seen growth in recent years



In **agricultural feedstock and chemicals**, Figure 7 shows Maryland's few jobs represented by a small bubble. Other summary highlights and comparisons in the subsector include the following:

Though the majority of the benchmark states are not considered to be specialized or among the national leaders in the ag-bioscience subsector or in its biofuels component, North Carolina does have a leading, specialized, and growing presence in the subsector (4,635 jobs; LQ is 1.50; 3 percent growth). North Carolina is large and specialized in the production of pesticides and other ag chemicals, in addition to phosphatic fertilizers and cellulosic organic fiber manufacturing. North Carolina is a good example of the potential for a varied subsector with a diverse, cross-industry employment base. In 2006, the subsector in Maryland employed almost 400 across just 19 establishments. The state's job total in this ag-bioscience subsector decreased by about 200 jobs, or 35 percent, between 2001 and 2006.

New Jersey has experienced strong job growth in the ag-bioscience subsector, with 28 percent job growth between 2001 and 2006 despite national subsector employment declines. New Jersey is nearly specialized, with a 1.15 LQ in 2006 and a large presence in the "all other basic organic chemical manufacturing" industry.

California is the largest employer among the benchmark states with about 5,200 jobs in 2006, largely in basic organic chemicals and in nitrogenous fertilizers. California's ag-bioscience subsector grew by 9 percent between 2001 and 2006 but is not considered specialized.

Figure 7. Agricultural feedstock and chemicals subsector, Maryland vs. benchmark states, 2006; little presence for Maryland

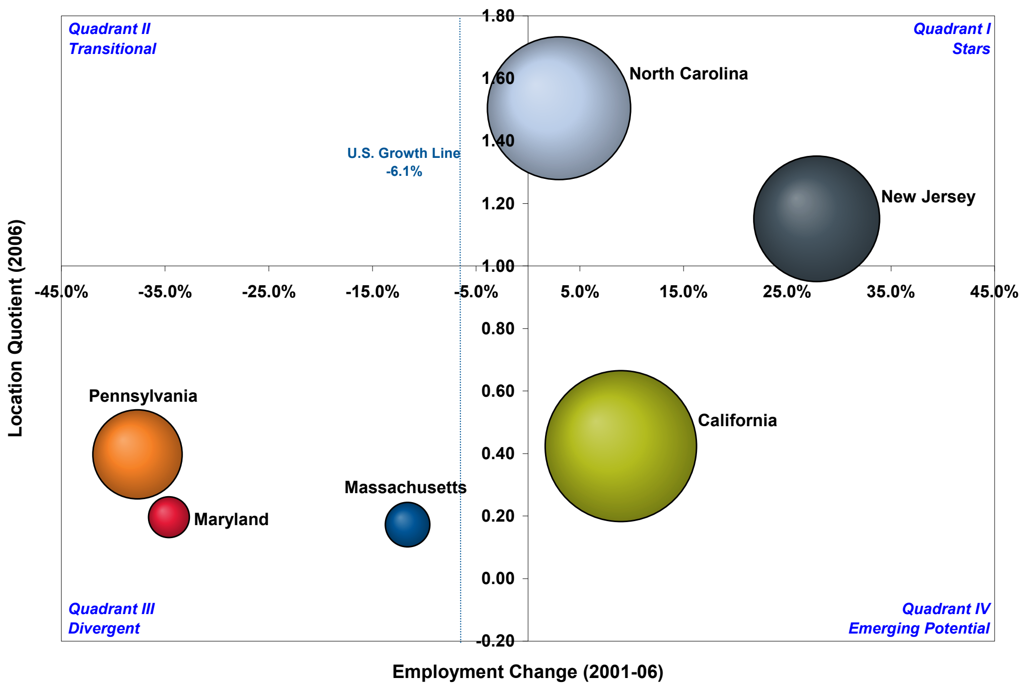


Figure 8 represents the sum of the four major bioscience subsectors. Maryland's position as an emerging state in the overall bioscience sector is evident as is its relatively modest size compared with five of the national leaders in the biosciences. Other summary highlights and comparisons in the overall bioscience sector include the following:

To put the benchmark states in context, all five states rank in the top 10 in bioscience employment totals for 2006. By comparison, although a clear leader in bioscience R&D and a leader by other measures as well, Maryland ranks 17th in overall bioscience employment (the state ranks 19th in total state population).

The five benchmark states have specialized employment concentrations in the biosciences, with New Jersey having the highest LQ at 2.19 in 2006. Maryland's LQ stands at 1.07 or 7 percent greater concentration than the national average. However, compared with its benchmark states, Maryland has a less concentrated employment base in the biosciences and must continue its rapid growth to narrow this specialization gap.

California, New Jersey, and Pennsylvania are the three largest bioscience employer states in the United States. California, by far the largest, employs nearly 200,000; New Jersey employs about 83,700; and Pennsylvania employs more than 77,400.

Maryland and the benchmark states showed net job growth between 2001 and 2006, although a few states lagged the U.S. growth rate of 5.7 percent during this period. Maryland's rapid 14.5 percent growth rate was exceeded among this group only by North Carolina, which has grown by 18.5 percent with employment gains in all four major subsectors.

Figure 8. Total bioscience sector, Maryland vs. benchmark states, 2006; Maryland is emerging in the biosciences but remains less specialized than the benchmark states

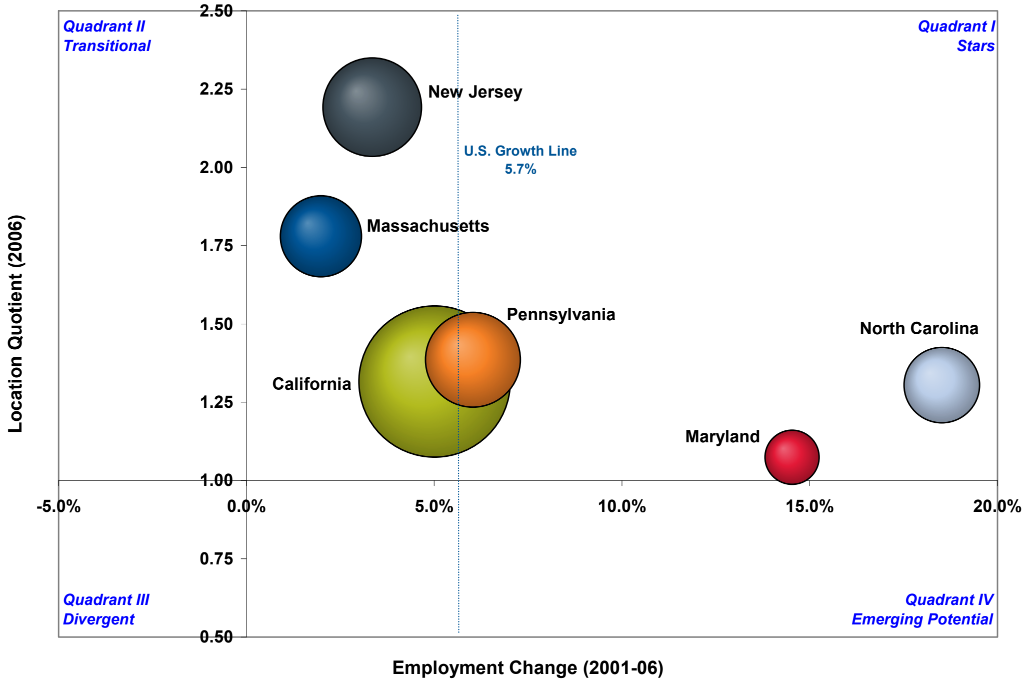
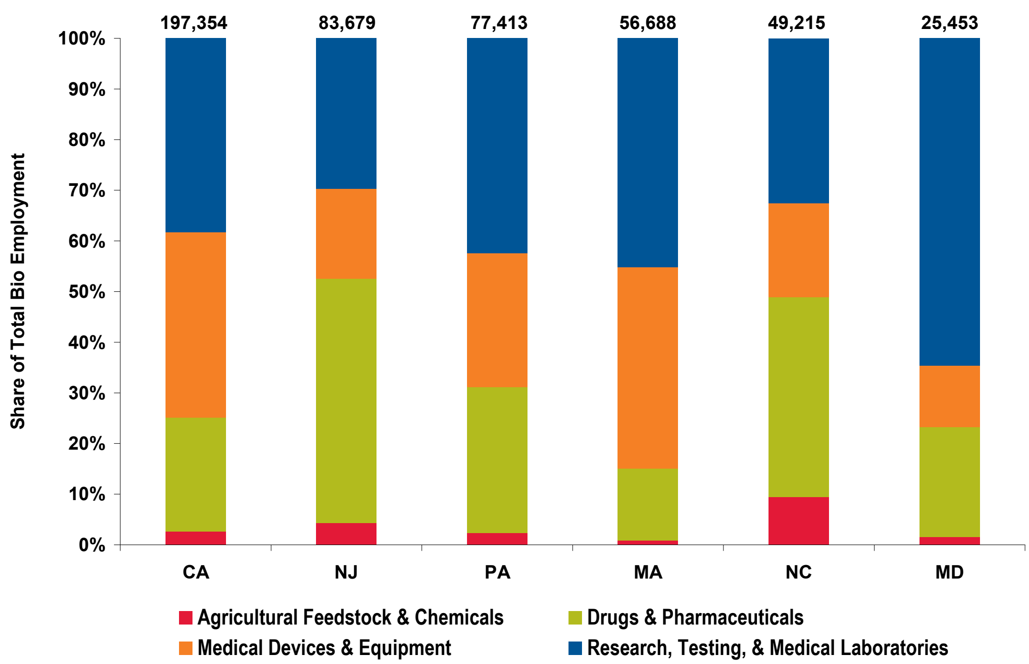


Figure 9 presents a comparative look at the composition of the four major bioscience subsectors in Maryland versus the five benchmark states. **Overall, Maryland has a much less diverse bioscience industry base compared with the benchmark states**. Two-thirds of Maryland's bioscience jobs are in the research, testing, and medical labs subsector; by contrast, among the benchmark states, no individual subsector exceeds 50 percent of the total.

Figure 9. Employment composition of the bioscience sector, Maryland vs. benchmark states, 2006; Maryland is less diverse in the composition of its bioscience sector compared with benchmark states

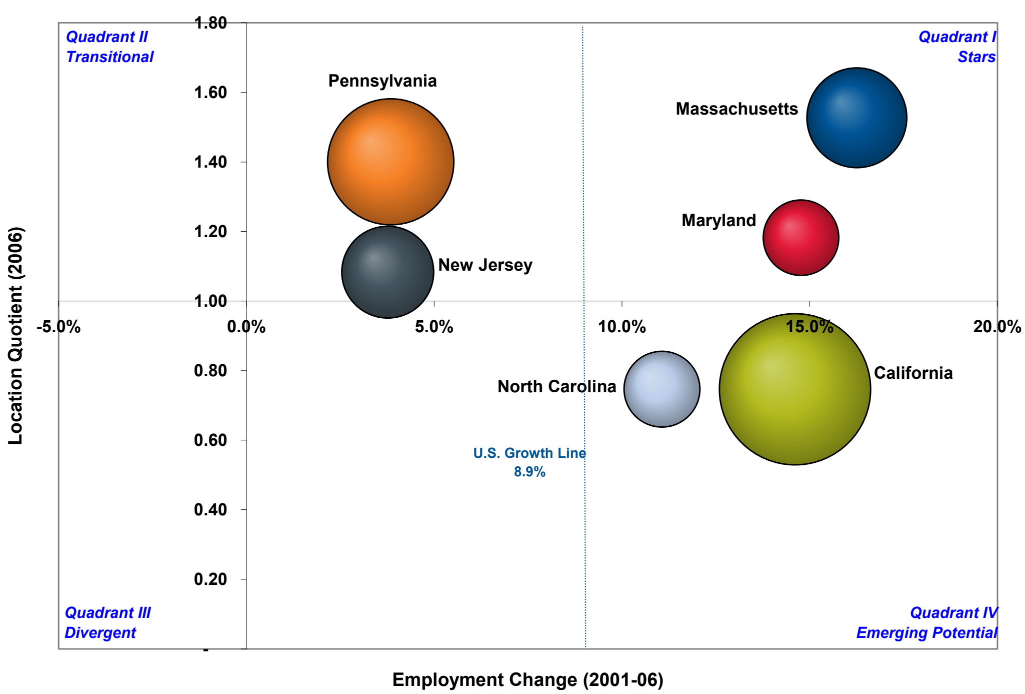


Although **hospitals** are not officially considered a bioscience subsector in the Battelle industry definition, they clearly play a key role in biomedical R&D and in the application of cutting-edge bioscience technologies and services. Despite the inability to isolate research and teaching institutions for this analysis, Figure 10 presents the overall subsector to provide useful comparisons across states and to highlight the importance of Maryland's hospitals to its economy and to the biosciences. Key highlights of the comparative analysis include the following:

Maryland is nearly specialized in its hospital subsector—its 2006 LQ is 1.18 or 18 percent greater concentration of hospital jobs than the national average. In addition, the subsector grew by 15 percent between 2001 and 2006, compared with 9 percent growth nationwide. Within the hospitals subsector, the detailed sub-industries in Maryland show a high degree of job concentration, including psychiatric and substance abuse hospitals (3,600 jobs; 2.08 LQ) and specialty hospitals (4,500 jobs; 1.51 LQ).

Employment in hospitals tends to reflect regional population; thus, the larger benchmark states in Figure 10 show larger bubbles. Massachusetts is highly specialized (1.53 LQ) and growing its hospitals subsector at a rapid pace (up 16 percent between 2001 and 2006). Pennsylvania also has a specialized hospitals subsector (1.40 LQ) but has seen slower job growth during the same time period, with an increase of less than 4 percent.

Figure 10. Hospitals, Maryland vs. benchmark states, 2006; Maryland, one of a few states with a specialization in the hospitals subsector, shows rapid growth in recent years



Bioscience R&D Position

Driving innovation in the bioscience sector are the R&D activities of a range of institutions, both public and private. To gauge the full reach and impact of Maryland's bioscience sector, these critical R&D activities must be quantified across not only private Industry, but also academia and the federal government. This section will summarize Maryland's current position in bioscience-related R&D expenditures and compare the state against the five benchmarks.

Data presented in this analysis come from the National Science Foundation (NSF) R&D surveys and represent the most current annual data across three key bioscience R&D metrics—university R&D expenditures (2007), industry R&D expenditures (2006), and the intramural R&D expenditures within the Department of Health and Human Services (HHS) (2004, the most current available data). The Data and Methodology Appendix contains more information on these data.

Table 3 summarizes bioscience-related R&D expenditures in Maryland and across the five benchmark states. **Taken together, Maryland's bioscience research complex represents $7.7 billion in R&D expenditures and is third among these states in R&D spending, behind California ($15.4 billion) and New Jersey ($10.0 billion)**. **On a per capita basis, however, Maryland has the most concentrated base of bioscience R&D in the nation.**

Maryland stands alone in its huge intramural funding base from HHS, with $4.9 billion as of 2004. This is not surprising since the state is home to the NIH and its affiliated centers of research. In university R&D in the biosciences, Maryland is about average in size among the benchmark states ($1.3 billion), though California is clearly the national leader ($4.2 billion). Maryland's industry R&D activity is small compared with the benchmark states—at $1.5 billion in 2006, it was the lowest among these states. New Jersey's strength in bioscience R&D is clearly within industry and, at $9.6 billion, compares favorably with California in this metric.

Table 3. Bioscience R&D expenditures, Maryland and benchmark states

State	University R&D in the Biosciences, 2007	HHS Intramural R&D, 2004	Industry R&D in the Biosciences*, 2006
MD	**$1.3 Billion**	**$4.9 Billion**	**$1.5 Billion**
CA	$4.2 Billion	$5.5 Million	$11.1 Billion
MA	$1.1 Billion	$1.1 Million	$4.1 Billion
NJ	$0.4 Billion	$1.5 Million	$9.6 Billion
NC	$1.5 Billion	$137 Million	$1.8 Billion
PA	$1.5 Billion	$10.8 Millon	$5.3 Billion

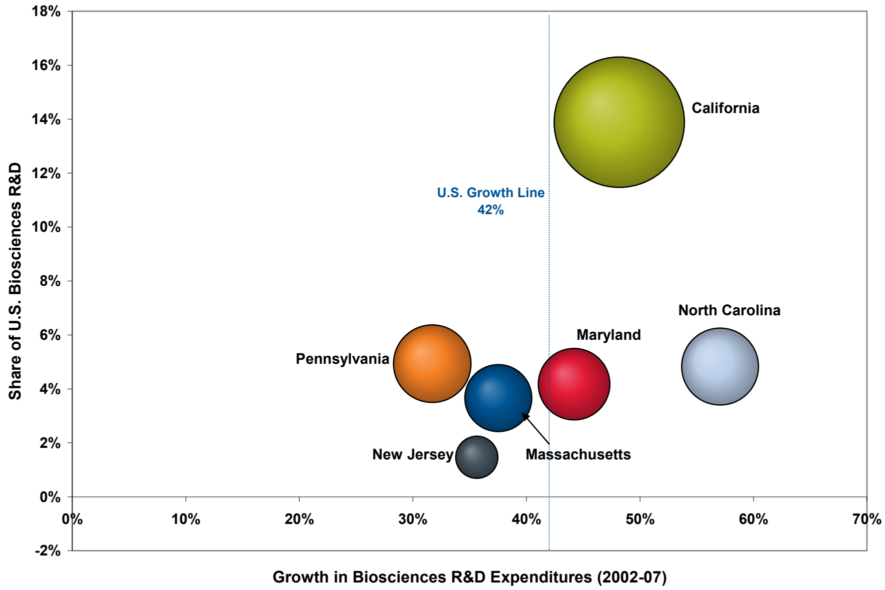
*Industry R&D includes pharmaceuticals, medical devices, and all scientific R&D services (not exclusive to biosciences).

Source: Battelle analysis of NSF Surveys of R&D, multiple years.

Maryland's academic institutions have grown their bioscience R&D expenditures at a rapid rate. Between 2002 and 2007, academic R&D in the state grew by 44 percent, just outpacing total national institutional growth at 42 percent. Figure 11 provides a summary of university R&D expenditures in the biosciences for Maryland and each benchmark state. Similar to the industry bubble charts, Figure 11 represents three key variables that track recent performance—R&D expenditures (size of bubble), state concentration relative to the nation, and recent growth (2002 to 2007).

California's $4.2 billion in academic bioscience R&D expenditures represents a significant 14 percent share of national expenditures. Perhaps even more impressive is the fact that this very large base continues to grow in California and outpace the nation, rising 48 percent between 2002 and 2007. North Carolina, with a slightly greater R&D base than Maryland, outgrew each of the benchmark states during this same time period, adding 57 percent to its base of university bioscience R&D dollars. New Jersey has, by far, the lowest level among the benchmark states of bioscience R&D expenditures in its universities, just $444 million in 2007.

Figure 11. Bioscience R&D expenditures in the benchmark states, share of U.S. total, recent growth, and size, 2007; Maryland shows above-average growth in recent years



Maryland's Bioscience R&D Complex: The Role of Federal Funding

A closer examination of Maryland's R&D base reveals the even greater role federal funding (HHS) plays as a sponsor of state, industry, and university R&D. Not only does Maryland have the largest HHS intramural funding in the nation, but HHS funding accounts for at least **78 percent of Maryland bioscience Industry R&D as well as nearly 70 percent of Maryland university bioscience** R&D.

The table below shows this relationship among the benchmark states in 2004 (most recent data available). The green shading highlights the 78 percent of total Maryland industry bioscience R&D funding that originates from HHS.

	Maryland	California	Massachusetts	New Jersey	North Carolina	Pennsylvania
HHS Funded R&D - FY04						
Total R&D	$6,816,830,000	$3,153,249,000	$2,215,281,000	$272,112,000	$1,114,665,000	$1,387,151,000
Intramural	$4,929,437,000	$5,536,000	$1,145,000	$1,500,000	$137,338,000	$10,814,000
Industry	$917,495,000	$262,004,000	$208,289,000	$39,150,000	$115,827,000	$37,837,000
Universities & Colleges	$790,183,000	$2,085,544,000	$870,725,000	$209,706,000	$788,896,000	$1,047,824,000
Other Nonprofits	$178,177,000	$794,575,000	$1,134,105,000	$21,026,000	$68,143,000	$284,960,000
State/Local Governments	$1,538,000	$5,590,000	$1,017,000	$730,000	$4,461,000	$5,716,000
Industry Performed R&D-2004						
Pharmaceuticals and medicines	$565,000,000	$4,535,000,000	$1,427,000,000	$5,701,000,000	$1,154,000,000	$3,146,000,000
Medical equipment and supplies	$40,000,000	$624,000,000	$414,000,000	$187,000,000	$27,000,000	$110,000,000
Scientific R&D services	$567,000,000	$4,053,000,000	$964,000,000	$620,000,000	$302,000,000	$622,000,000

Bioscience Innovation Activity—Venture Capital Investments and Patents

Venture Capital

Business development in the biosciences requires not only significant R&D dollars, but also substantial funds necessary to bring a new product or service to market. Major costs beyond the research stage include clinical trials, regulatory filings, market assessment (pricing, competition, prototypes, sales plans), followed by actual production, distribution, and sales. Sufficient capital is necessary in order to grow a business through each major stage and milestone. Venture funding is one avenue for obtaining necessary and sufficient capital requirements, especially in the critical seed and early stages.[4]

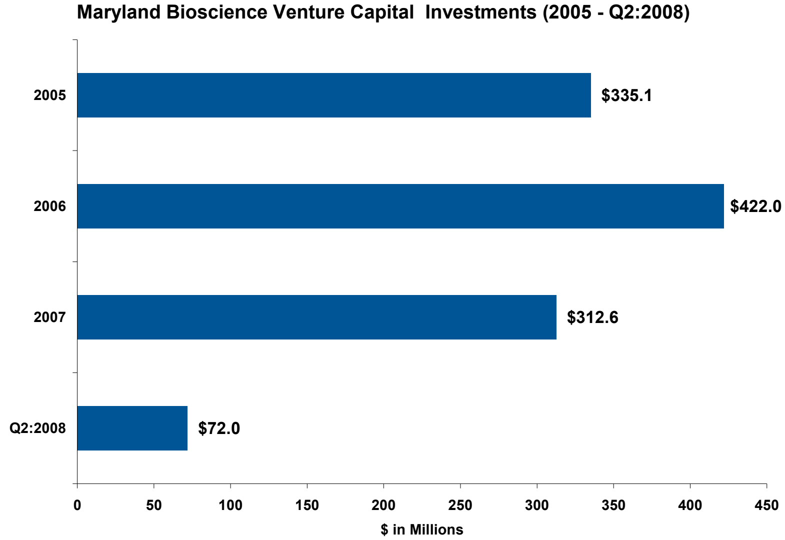
This section presents an analysis of recent venture-capital investments in Maryland and the five benchmark states. By analyzing the dollars and deal flow of venture financing, insights are gained into the relative ability of new and established companies to operate with effective capital. Given the relative volatility in venture funding and investments over time, much of the data presented here are aggregated over the most recent 3.5 years and cover 2005 through the second quarter of 2008. Data presented in this analysis are from the Thomson VentureXpert database. The Data and Methodology Appendix provides more information on the source of these data.

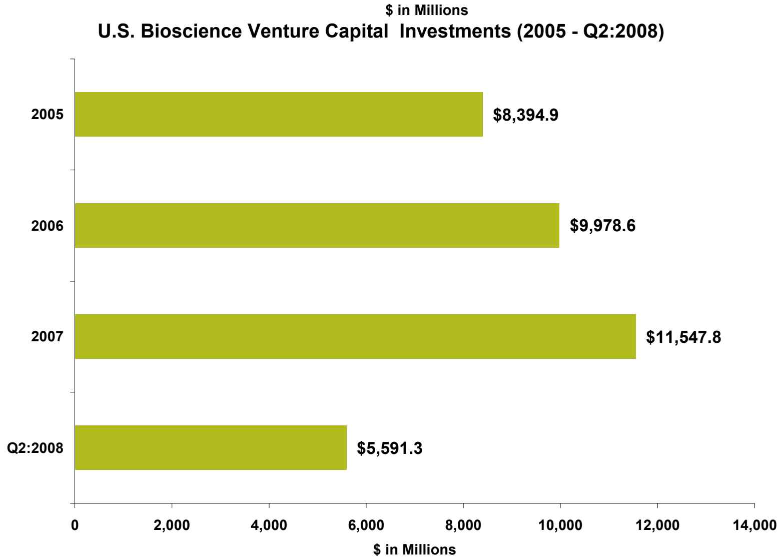
Venture funding in Maryland's bioscience companies totaled $1.1 billion during the period from 2005 through the second quarter of 2008. Among the benchmark states, California excels in venture funding targeted at bioscience companies. Since 2005, California bioscience-related firms have received $15.1 billion dollars, more than three times that of the next largest state recipient, Massachusetts, which totaled $4.5 billion during this same period. Pennsylvania is next among the benchmark states at $2.0 billion, followed by New Jersey at $1.5 billion, and Maryland and North Carolina each at $1.1 billion.

Though venture capital investments can fluctuate on a year-to-year basis, Maryland's have declined since 2006, while the nation and benchmark states continue to increase their level of bioscience venture-capital investment (Figure 12). The $72 million invested during the first 6 months of 2008 puts Maryland's bioscience firms on track for only $144 million over the year—well below the totals for recent years and marking a major decline in venture capital. Further, venture funds invested in bioscience companies, both nationally and in the benchmark states, are on pace for another strong year in 2008, which suggests that the problem may be specific to Maryland. **As a result, Maryland's share of national bioscience venture-capital funds, which was at 4.0 percent in 2005 and 4.2 percent in 2006, fell to 2.7 percent in 2007 and just 1.3 percent through the first half of 2008.**

[4] Venture capital is by no means the only funding mechanism for bioscience companies. "Angel" and other investments made by individuals are also important, but typically less public (and therefore more difficult to track). To some extent, the Thomson VentureXpert database does pick up large angel investments when funds are co-invested with a venture capital entity.

Figure 12. Bioscience venture-capital investments in Maryland and the United States, 2005–Q2:2008; Maryland's share of the nation's bioscience venture-capital investments has declined from 4.0 percent in 2005 to 1.3 percent through Q2 2008

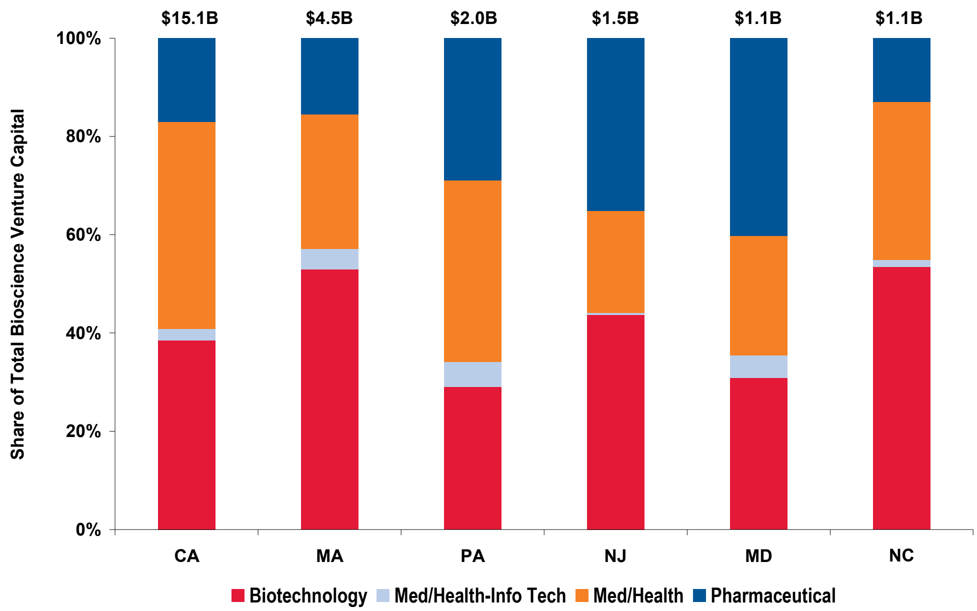




The largest percentage of bioscience venture-capital investments in Maryland is targeted to companies in the pharmaceutical segment (Figure 13). **Since 2005, 40 percent ($459 million) of venture funding in Maryland's bioscience sector has been directed at pharmaceuticals and 31 percent ($353 million) at biotechnology (primarily in human biotech).** This focus within the state on pharmaceuticals is consistent with the large presence of a product-oriented bioscience R&D industry in Maryland. As these companies succeed in their product development, they will be entering the pharmaceutical and perhaps medical device industries.

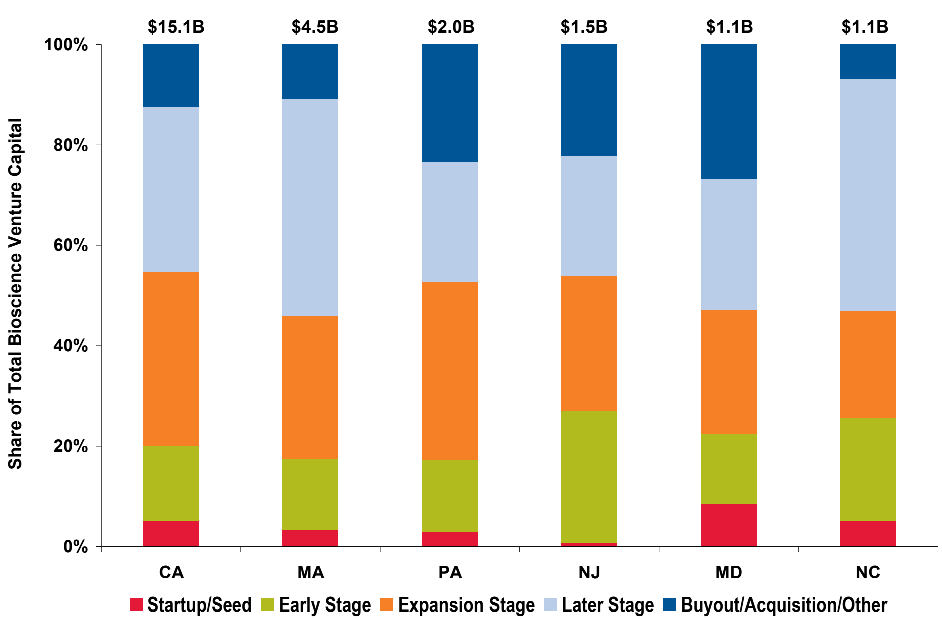
In the 2008 Battelle-BIO report, the venture-capital investment analysis by detailed company segment showed Maryland among the top 5 states nationally in five different categories—pharmaceuticals, biosensors, animal biotech, industrial biotech, and med/health-related information technology (IT) and software.

Figure 13. Bioscience venture-capital investments by major segment, Maryland and benchmark states, 2005–Q2:2008; bioscience venture-capital money in Maryland is directed mostly to pharmaceuticals and biotech



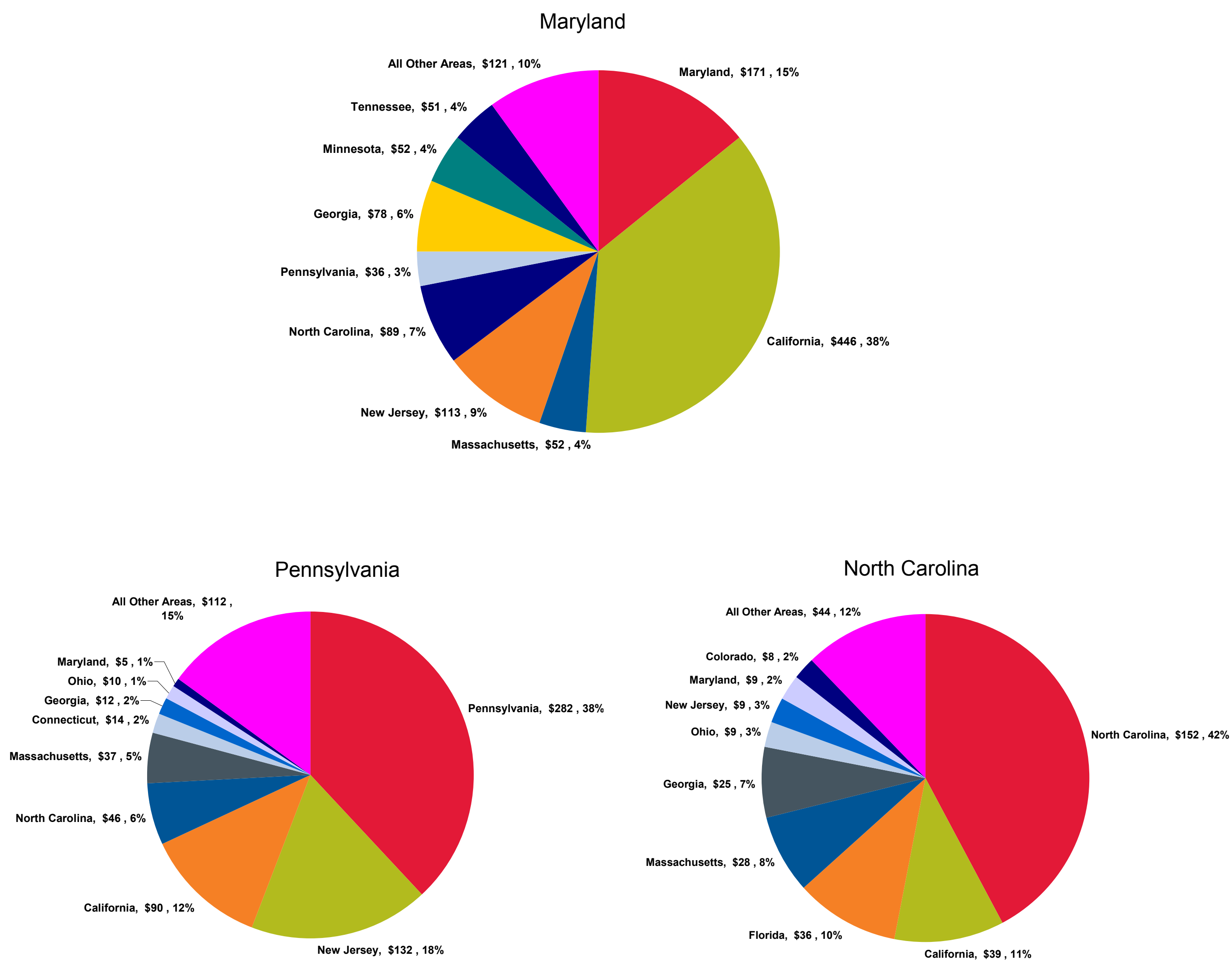
Bioscience leaders in Maryland express a common concern that there is insufficient early-stage venture-capital investment critical to enabling emerging bioscience companies to succeed. Figure 14 shows the distribution of bioscience venture-capital funds by stage for Maryland and the five benchmark states since 2005 with total venture-capital investments labeled at the top of each column. **Maryland stands out in its share of funding at the critical start-up/seed stage of a firm's inception with 9 percent of investments, or about twice the average share of the benchmark states, targeting this stage. When start-up/seed investments are combined with the just-as-critical early-stage investments, however, the 20 percent share for Maryland companies is much more comparable to other states.**

Figure 14. Bioscience venture-capital investments in Maryland and benchmark states by stage, 2005–Q2:2008; Maryland excels in share of start-up/seed dollars but less so when combined with early-stage dollars



Another often-heard concern involves the lack of bioscience venture-capital funds under management in Maryland. In fact, Maryland venture-capital firms invested $1.2 billion in bioscience companies from 2005 through the second quarter of 2008—a significantly higher amount than in Pennsylvania ($741 million) or North Carolina ($359 million). **However, of that $1.2 billion invested in bioscience companies by venture-capital firms located in Maryland, only 15 percent was invested in Maryland bioscience companies**. While significantly higher than the 3 percent to 4 percent share of overall bioscience venture-capital investment nationally that Maryland has realized, it is still well below the 42 percent and 38 percent in North Carolina and Pennsylvania, respectively, invested by locally based venture-capital firms (Figure 15).

Figure 15. Bioscience investments by Maryland, Pennsylvania, and North Carolina venture-capital firms, by state, 2005–Q2:2008 ($ in millions); Maryland venture-capital firms are investing a smaller share in-state compared with counterparts in Pennsylvania and North Carolina



Bioscience-Related Patents

Innovation is a critical element in a research-oriented sector such as the biosciences. Developing novel ideas, processes, and products characterizes the commercialization of the biosciences and propels the industry in new directions. Intellectual property in the form of patents offers legal protections for new ideas and fosters continued innovation in the United States. An analysis of bioscience-related patents in Maryland and the benchmark states signals the allocation of bioscience resources, both in money and time investments, and the extent to which the citizens and firms of each state are driving innovation.

The U.S. Patent and Trademark Office (USPTO) assigns each patent to a specific numeric primary patent "class." When relevant patent classes are combined across the array of bioscience-related activity, these class designations allow for an aggregation specific to the biosciences. Battelle has grouped these relevant patents into broader patent groupings for this analysis.[5] The data presented here represent patent activity from 2005 through the second quarter of 2008.

Table 4 presents the bioscience-related patent activity of Maryland and the five benchmark states. In the table, detailed patent classes are grouped with related classes in their appropriate bioscience context. **From 2005 through the second quarter of 2008, 2,045 Maryland patents were issued relating to the biosciences. Among the benchmark states, only North Carolina had fewer bioscience-related patents than Maryland. California leads all states in patent activity with more than 13,000 since 2005. On a per-capita basis, Maryland's patent activity compares more favorably with these larger states—Maryland matches California and is third (behind Massachusetts and New Jersey).**

Table 4. Bioscience-related patents by patent class and major group, 2005–Q2:2008; only North Carolina had fewer patents issued than Maryland among benchmark states

Main Patent Class	CA	MA	NJ	PA	MD	NC
Agricultural Bioscience						
Chemistry: fertilizers	6		1			
Plant protecting and regulating compositions	7	4	5	6	1	15
Plants	516	23	21	15	8	31
Biochemistry						
Chemistry: analytical and immunological testing	296	82	58	46	46	25
Chemistry: molecular biology and microbiology	2,246	803	396	460	591	210
Chemistry: natural resins or derivatives; peptides or proteins	833	204	111	95	215	45
Organic compounds -- part of the class 532-570 series	385	132	76	80	76	46
Biotechnology						
Multicellular living organisms and unmodified parts	273	39	29	73	46	80
Drugs & Pharmaceuticals						
Drug, bio-affecting and body treating compositions	2,894	1,322	1,553	1,183	639	470
Other Medical Equipment						
Dentistry	199	16	12	23	6	4
Medical and laboratory equipment	290	77	113	78	14	35
Optics: eye examining, vision testing and correcting	228	31	16	23	14	5
Prosthesis parts, aids, and accessories	443	161	156	67	27	22
Surgical & Medical Instruments						
Surgery	247	52	25	64	30	32
Surgery: blood/fluid-related devices	587	195	143	109	32	46
Surgery: diagnostic/therapy testing, techniques, or devices	833	243	131	99	85	44
Surgery: kinesitherapy	79	9	14	15	12	3
Surgery: light, thermal, and electrical application	662	76	28	31	44	15
Surgery: splint, brace, or bandage	92	13	12	11	10	10
Surgery: surgical instruments and devices	1,021	342	124	125	33	48
Other Bioscience-Related						
Total, other bioscience-related	1,120	284	262	199	116	103
Total Bioscience-Related Patents						
Total, all bioscience-related	**13,257**	**4,108**	**3,286**	**2,802**	**2,045**	**1,289**

Source: Battelle analysis of USPTO/Delphion data.

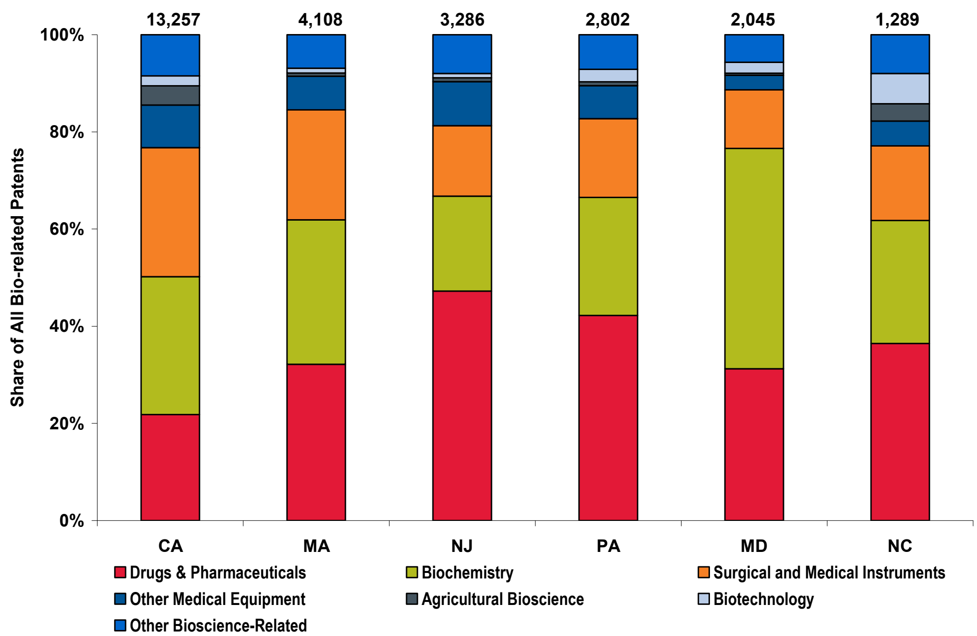
[5] For the Battelle definition of bioscience-related patents and their major groups, see the Data and Methodology Appendix.

Maryland's greatest concentration in bioscience-related patents is in the major biochemistry group, which since 2005 accounts for 928 patents or 45 percent of the state's total bioscience-related patents. The focus for Maryland inventors within biochemistry is largely in molecular biology and microbiology. Maryland has more patents in this individual patent class than all benchmark states but California and Massachusetts.

In the 2008 Battelle-BIO report, bioscience-related patent activity was summarized and analyzed across states for the longer, 2002 to 2007 period. In this analysis, Maryland ranked seventh among all states in overall bioscience patents. In addition, among the major class groups, Maryland ranked among the top 5 states in biochemistry.

Figure 16 presents the composition of bioscience-related patents for Maryland and the benchmark states. Maryland's relative share of biochemistry patents is evident in the green section of the column (45 percent of its patents). Large drug R&D and producer states like New Jersey and Pennsylvania have large shares, 40 percent or greater, in the drugs and pharmaceuticals group, while Maryland has 31 percent by comparison. California's patent distribution is much more varied, with remarkably equal shares in drugs, biochemistry, and surgical and medical instruments, reflecting the state's large and diverse bioscience industry and academic research base.

Figure 16. Bioscience-related patents by major class group, 2005–Q2:2008; biochemistry patents account for 45 percent of Maryland bioscience patents issued since 2005



Bioscience Workforce Development

A core of talent spanning a wide range of highly skilled occupations is critical to developing and growing a region's bioscience industry and research base. In the biosciences, states must often develop talent around several distinct niches and subsectors, addressing talent needs from skilled technicians and production workers in medical device manufacturing to Ph.D. scientists and researchers working to develop the next generation of therapeutics or other pharmaceuticals. States must nurture and develop both their home-grown talent, as well as talent "imported" from other regions in order for the overall sector to thrive well into the future.

Maryland is well positioned for generating a broad base of bioscience workforce with the presence of not only research universities and 4-year schools, but also a community college system that is actively pursuing degrees in biotechnology that enable technicians and production workers in this high-skill sector.

Industry employment is useful in assessing the broad reach and impacts of a region's bioscience or other sectors on the economy; from a workforce perspective, however, the more appropriate analytical framework involves focusing on occupational employment. The broad bioscience industry employs individuals across a wide spectrum of often vastly different occupations—from administrative staff and IT professionals, to finance and accounting workers and scientists. By honing in on the core bioscience occupations (scientists, biomedical workers, etc.), the analysis is both refined in an occupational sense as well as expanded to track these workers across all industries.

Battelle's bioscience strategy and core competency work across the country has led to an identified core set of key bioscience-related occupations. These occupations typically account for the range of core innovation activities in most nonclinical bioscience companies. While numerous other occupations are important to the full operations and activities of bioscience companies, the focus of this analysis is on this base of talent. Table 5 lists 15 occupations that come from the Standard Occupational Classification (SOC) system used by the federal statistical system and details them along with their major groupings.

Table 5. Bioscience-related nonclinical occupations, major groups, and SOC codes

Bioscience Occupations and Groups	SOC Code
Agricultural, Food and Nutrition Scientists and Technicians	
Soil and Plant Scientists	19-1013
Animal Scientists	19-1011
Agricultural and Food Science Technicians	19-4011
Biological Scientists and Technicians	
Microbiologists	19-1022
Epidemiologists	19-1041
Medical Scientists, Except Epidemiologists	19-1042
Biological Scientists, all other	19-1029
Biological Technicians	19-4021
Biomedical and Biochemical Scientists and Engineers	
Biomedical Engineers	17-2031
Biochemists and Biophysicists	19-1021
Medical and Clinical Laboratory Technicians	
Medical and Clinical Laboratory Technologists	29-2011
Medical and Clinical Laboratory Technicians	29-2012
Dental Laboratory Technicians	51-9081
Medical Appliance Technicians	51-9082
Ophthalmic Laboratory Technicians	51-9083

For each of the major occupational groups and their more detailed components, employment levels, trends, and concentration relative to total employment were tabulated to identify state specializations and growth in Maryland compared with its peers. Data for Maryland and the benchmark states are from the Occupational Employment Statistics (OES) program and were provided by the U.S. Bureau of Labor Statistics (BLS).

Table 6 summarizes occupational employment across the major groups as aggregated by Battelle. The table also includes a national size ranking among these occupations from the 2008 Battelle-BIO report. Maryland has a sizable base of core bioscience-related occupational employment and ranks well, but is not a national leader. It is important to understand that, unlike the industry employment data presented earlier, these data include not only private-sector workers but also the talent base across government associated with Maryland's full bioscience research complex. In total, Maryland employs 18,250 in these occupations with an especially large concentration in biological scientists and technicians. **This total is large enough to rank the state 11th overall in its base of bioscience occupational talent.**

Table 6. Bioscience-related occupational employment by major groups, 2006

STATE	Agricultural, Food & Nutrition Scientists & Technicians	Biological Scientists & Technicians	Biomedical & Biochemical Scientists & Engineers	Medical & Clinical Laboratory Technicians	Total, All Bio-Related Occupations, 2006	National Occupational Ranking, 2006
California	5,380	34,510	7,380	22,330	69,600	1
Pennsylvania	970	11,300	2,350	20,160	34,780	2
Massachusetts	490	13,110	3,330	13,850	30,780	5
New Jersey	790	8,210	1,710	7,870	18,580	8
North Carolina	1,550	6,130	1,460	9,370	18,510	9
Maryland	**690**	**10,480**	**630**	**6,450**	**18,250**	**11**

Source: Battelle analysis of BLS, OES data.

Within the broader occupation groups are a range of sizable and highly specialized occupations within Maryland. Table 7 presents updated data for Maryland in 2007 across all available detailed bioscience-related occupations.[6] **Taking all bioscience-related occupations together, Maryland has a specialized concentration of these core jobs. The state's 2007 LQ across these occupations is 1.44 or a 44 percent greater concentration of key bioscience talent in Maryland compared with the national average**. By comparison, only Massachusetts and Pennsylvania among the benchmark states have specialized occupational bases in the biosciences, with LQs of 2.19 and 1.34, respectively.

Maryland has six highly specialized bioscience occupations (those with a state LQ greater than 1.20 highlighted in red in Table 7) that span a range of high-skilled science, engineering, and technician jobs. These specialized occupations are biological scientists (all other), microbiologists, biological technicians, epidemiologists, biomedical engineers, and medical scientists (except epidemiologists).

Table 7. Detailed bioscience-related occupational employment in Maryland, 2007

Occupation	Maryland	
	2007 Employment	LQ
Total Employment, All Occupations	**2,551,910**	**1.00**
Medical and Clinical Laboratory Technologists	3,280	1.06
Biological Scientists, All Other	2,760	**5.37**
Biological Technicians	2,740	**2.09**
Medical Scientists, Except Epidemiologists	2,640	**1.59**
Medical and Clinical Laboratory Technicians	2,570	0.93
Microbiologists	1,350	**4.86**
Dental Laboratory Technicians	590	0.70
Ophthalmic Laboratory Technicians	560	0.95
Biomedical Engineers	500	**1.71**
Agricultural and Food Science Technicians	400	1.09
Biochemists and Biophysicists	280	0.76
Soil and Plant Scientists	160	0.82
Medical Appliance Technicians	160	0.71
Epidemiologists	150	**1.99**
Animal Scientists	90	1.13
Total Biosciences	**18,230**	**1.44**

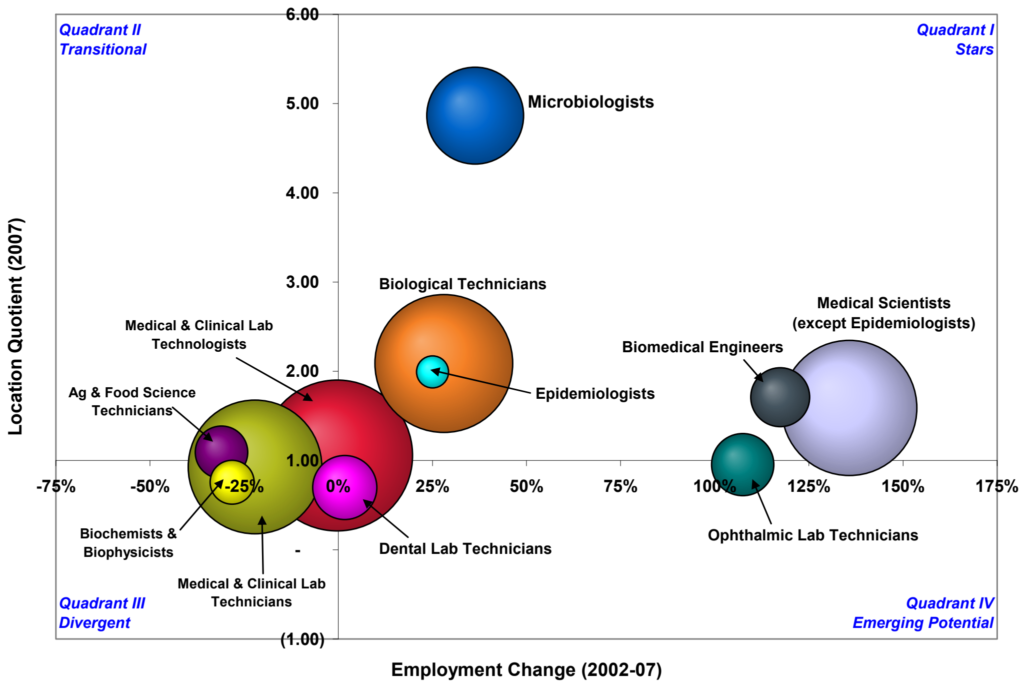
Source: Battelle analysis of BLS, OES data.

Figure 17 captures recent trends in Maryland's detailed bioscience-related occupational employment. A number of the specialized occupations have shown impressive growth since 2002

[6] The Data and Methodology Appendix contains a full version of Table 7 for Maryland and all five benchmark states.

including medical scientists, biomedical engineers, biological technicians, microbiologists, and epidemiologists.

Figure 17. Maryland bioscience-related occupations, degree of specialization, employment growth, and



size, 2007; Maryland has an impressive talent base in several highly specialized bioscience occupations

Technology Transfer and Commercialization

Successful commercialization and transfer of technologies from universities, clinical hospitals, and other research institutions to industry play a major role in economic development and growth. By licensing or transferring cutting-edge technologies from institutions to industry, the innovation begun in the lab or at the drawing board can be more fully realized in a full-scale commercial application. With respect to the biosciences, technologies not only translate into commercial success but also have broader societal impact by improving or saving lives.

Table 8 summarizes information for Maryland institutions collected by the Association of University Technology Managers (AUTM) in its annual survey of members (2006). The annual survey by AUTM is limited with respect to a specific, bioscience-focused analysis because its members are not asked to provide information that would allow for the coding of responses by industry sector. Thus, the data presented here are not for the biosciences exclusively; nevertheless, they shed light on the overall climate for the transfer and commercialization of technologies in Maryland. Though the data in Table 8 do not include summary data for all institutions across the five benchmark states, they include specific institutions in the United States that are highly focused in the biosciences and provide useful comparisons in that respect.

Table 8. Technology transfer data for Maryland institutions and other selected institutions, 2006

State/Institution	2006 Invention Disclosures	2006 Startups	Metrics Per $10M in Research Expenditures: 2006 Invention Disclosures	2006 New Patent Applications	2006 U.S. Patents Issued	2006 Licenses & Options Executed	2006 License Income
Maryland, Total*	**621**	**8**	**2.9**	**2.8**	**0.58**	**0.5**	**$ 76,247**
Johns Hopkins University	363	6	2.1	1.9	0.47	0.4	$ 79,319
University of Maryland Biotechnology Institute	32	0	9.4	8.5	1.46	1.5	$ 106,036
University of Maryland, Baltimore	92	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
University of Maryland, Baltimore County	20	0	3.0	2.9	1.37	0.3	$ 24,888
University of Maryland, College Park	114	2	3.6	2.4	0.70	0.9	$ 59,698
M.D. Anderson Cancer Center	147	2	3.6	1.7	0.61	0.6	$ 154,424
Mayo Foundation for Medical Education & Research	302	9	6.7	2.1	0.65	2.1	$ 577,705
University of Pennsylvania	306	3	4.8	8.1	0.77	0.6	$ 128,941
University of Washington/Wash. Res. Foundation	310	10	3.3	0.9	0.40	1.7	$ 386,598
University of Wisconsin at Madison	464	7	5.6	2.4	0.83	1.9	$ 509,242

*Note: Maryland totals reflect insufficient information for UMD-Baltimore.

Source: Battelle analysis of AUTM Licensing Survey, FY 2006.

Table 8 presents selected technology transfer metrics that indicate positive outcomes for research—licenses executed and income received, patents issued, and startups initiated. Normalizing these data per $10 million in total research expenditures allows for a comparable measure of the relative return on each dollar of research in terms of successful outcomes.

One Maryland institution, Johns Hopkins University, is considered a national research "giant." Total sponsored research expenditures at JHU for 2006 (includes funding by all sources including federal and local government, industry, foundations, and other nonprofits) totaled nearly $1.8 billion. Among the individual institutions in the AUTM survey data, this research base for JHU led the nation. The University of Maryland at College Park is also a major research center, though not on the same level as JHU. At UM-College Park, total sponsored research expenditures for 2006 totaled $314 million.[7]

Overall, Johns Hopkins and other Maryland institutions are lagging top U.S. institutions also presented in Table 8 in the rate of disclosures, licenses, license income per research dollar, and start-ups (per disclosures). Despite this apparent lag among the major state research institutions, a smaller state institution, UM Biotechnology Institute, appears to be leveraging a smaller base of research dollars into successful outcomes. Normalizing the data on a "per research dollar" basis reveals that UMBI has executed 1.5 licenses per $10 million in research spending, more than any other Maryland institution relative to its research base. Institute researchers have been issued nearly 1.5 patents for those same research dollars, again more than its counterpart institutions in Maryland relative to research expenditures.

Maryland is also home to the NIH Office of Technology Transfer (OTT), located in Rockville, Maryland. OTT is responsible for protecting marketing and licensing the wide range of inventions made by its scientists—one of the largest portfolios of new technologies of any public research institution in the world. These activities facilitate public availability of the results of intramural research by providing incentives and opportunities for private-sector commercialization by bioscience companies in Maryland and other areas.

As a leader in public-sector technology transfer policy and practice, OTT's advice is sought by state, national, and international organizations. The NIH intramural research program has few peers when viewed in terms of the amount of royalties administered or the public health impact of its technology transfer efforts. More than 300 products, 25 of which are FDA approved, have reached the market containing inventive technologies licensed from the NIH. These include the first vaccines for human

[7] Ideally, AUTM data for the entire University of Maryland system (all campuses) might be aggregated; unfortunately, data for UM-Baltimore were not available, preventing this aggregate analysis.

papilloma virus and hepatitis A virus, three drugs for treating HIV, the first drug for treating multiple myeloma, some first-in-class *in vivo* diagnostics, and the most widely utilized drug-eluting cardiovascular stent. The blockbuster drug Synagis® that is manufactured in Maryland by MedImmune is also a licensed product from the NIH intramural research program. Over the years, licenses of NIH technologies have accounted for almost two-thirds of the royalties collected by all federal agencies combined—with total royalties from intramural inventions of $867 million and product sales by licensees of $45 billion.

Thus, many of these research efforts by the NIH intramural research program have had a significant impact on medical R&D and as such facilitated significant improvements in public health and economic development in Maryland as well as throughout the world.

APPENDIX: DATA AND METHODOLOGY

Industry Employment Analysis

The economic analysis in this report examines data for the nation, for Maryland, and for benchmark states and corresponding trends in the biosciences from 2001 to 2006. For employment analysis, Battelle used the Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW) data. The QCEW program (formerly known as the ES-202 program) provides the most current, detailed industry employment, establishment, and wage data available at both a national and subnational level.[8] Battelle receives an enhanced version of these state and county data from a private vendor, the Minnesota IMPLAN Group, Inc.

The QCEW program, a cooperative program involving BLS and the State Employment Security Agencies (SESAs), produces a comprehensive tabulation of employment and wage information for workers covered by state unemployment insurance (UI) laws and federal workers covered by the Unemployment Compensation for Federal Employees (UCFE) program. Publicly available files include data on the number of establishments, monthly employment, and quarterly wages, by NAICS (North American Industry Classification System) industry, by county, and by ownership sector, for the entire United States. These data are aggregated to annual levels, to higher industry levels (NAICS industry groups, sectors, and supersectors), and to higher geographic levels (national, state, and metropolitan statistical area [MSA]).[9]

Since 2001, the QCEW has been producing and publishing data according to the NAICS. Federal statistical agencies have a mandate to publish industry data according to this improved classification system. Compared with the prior classification system—the 1987 Standard Industrial Classification (SIC) system, NAICS better incorporates new and emerging industries. Employment, establishment, and wage estimates produced by the QCEW program for 2001 to present are not comparable with SIC-based industry estimates from prior years. This disparity prevents construction of a longer time series for data analysis; however, 6 years of NAICS-based data (2001 to 2006) are now available.

Twenty-seven NAICS industries at the most detailed (6-digit) level make up the Battelle definition of the biosciences and its subsectors (Table A-1). These detailed industries are aggregated up to four major subsectors of the bioscience Industry. Two of the detailed NAICS industries, testing laboratories (NAICS 541380) and physical, engineering, and biological research (NAICS 541710), are adjusted in this analysis to include only the share of these industries directly involved in

[8] In general, QCEW monthly employment data represent the number of covered workers who worked during, or received pay for, the pay period that included the 12th day of the month. Virtually all workers are reported in the state in which their jobs are located. Covered private-industry employment includes most corporate officials, executives, supervisory personnel, professionals, clerical workers, wage earners, piece workers, and part-time workers. It excludes proprietors, the unincorporated self-employed, unpaid family members, and certain farm and domestic workers. An establishment is an economic unit such as a farm, mine, factory, or store that produces goods or provides services. It is typically at a single physical location and engaged in one, or predominantly one, type of economic activity for which a single industrial classification may be applied. Total wages: Covered employers in most states report total compensation paid during the calendar quarter, regardless of when the services were performed. A few state laws, however, specify that wages be reported for or be based on the period during which services are performed, rather than for the period during which compensation is paid. Under most state laws or regulations, wages include bonuses, stock options, severance pay, the cash value of meals and lodging, tips and other gratuities, and—in some states—employer contributions to certain deferred compensation plans such as 401(k) plans.

[9] Major exclusions from UI coverage, and thus from the QCEW data, include self-employed workers, some wage and salary agricultural workers, unpaid family workers, railroad workers, and some state and local government workers.

biological or other bioscience activities. To isolate these relevant bioscience components, Battelle used information and data from the U.S. Census Bureau's Economic Census.

Table A-1. The bioscience subsector industries and NAICS codes

NAICS Code	Industry Description
Agricultural Feedstock & Chemicals	
311221	Wet corn milling
311222	Soybean processing
311223	Other oilseed processing
325193	Ethyl alcohol manufacturing
325199	All other basic organic chemical mfg.
325221	Cellulosic organic fiber manufacturing
325311	Nitrogenous fertilizer manufacturing
325312	Phosphatic fertilizer manufacturing
325314	Fertilizer, mixing only, manufacturing
325320	Pesticide and other ag. chemical mfg.
Drugs & Pharmaceuticals	
325411	Medicinal and botanical manufacturing
325412	Pharmaceutical preparation manufacturing
325413	In-vitro diagnostic substance manufacturing
325414	Biological product (except diagnostic) mfg.
Medical Devices & Equipment	
334510	Electromedical apparatus manufacturing
334516	Analytical laboratory instrument mfg.
334517	Irradiation apparatus manufacturing
339111	Laboratory apparatus and furniture mfg.
339112	Surgical and medical instrument manufacturing
339113	Surgical appliance and supplies manufacturing
339114	Dental equipment and supplies manufacturing
339115	Ophthalmic goods manufacturing
339116	Dental laboratories
Research, Testing, & Medical Laboratories	
541380*	Testing laboratories
541710*	Physical, engineering and biological research
621511	Medical laboratories
621512	Diagnostic imaging centers

*Includes only the portion of these industries engaged in biosciences activities.

More information on the BLS QCEW is available at http://www.bls.gov/cew/home.htm.

Bioscience Academic R&D Expenditures

Based upon data from the *National Science Foundation (NSF) Survey of Research and Development Expenditures at Universities and Colleges*,[10] national and state totals (summation of all state's responding institutions) are calculated for FY 2006 (most current year available). Data are provided for total research and development (R&D) expenditures (including per-capita measures) as well as in chart form for the bioscience fields including medical sciences, biological sciences, agricultural sciences, bio/biomedical engineering, and other biosciences.

Venture Capital

Venture capital investments, while not the only source of equity capital for bioscience firms, is often the largest and typically the most publicly known and reported source of investment funds allowing for comparability among states.

[10] http://www.nsf.gov/statistics/showsrvy.cfm?srvy_CatID=4&srvy_Seri=12.

Venture capital data were collected using the Thomson Reuters VentureXpert venture-capital database and includes all venture capital deals from January 1, 2005, through June 30, 2008. The analysis includes all investments categorized in VentureXpert in the medical/health/biosciences major category and four subcategories within the information technology major category that capture medical/health-related information technology applications (e.g., software, e-commerce, internet content, and internet services).

Bioscience-Related Patents

The use of patent data provides a surrogate (though imperfect) approach to understanding those innovations that bioscience-related industrial organizations, research institutions, and general inventors deem significant enough to register and protect and also provides some measure of comparability among regions in one facet of innovation. Furthermore, examining recent patent activity provides some insight into firms' recent R&D areas, and hence, potential future lines of business. Three types of patents are defined by the U.S. Patent and Trademark Office (USPTO):

- ***Utility*** patents, which may be granted to anyone who invents or discovers any new and useful process, machine, article of manufacture, or composition of matter, or any new and useful improvement thereof.
- ***Design*** patents, which may be granted to anyone who invents a new, original, and ornamental design for an article of manufacture.
- ***Plant*** patents, which may be granted to anyone who invents or discovers and asexually reproduces any distinct and new variety of plant.

Additionally, patents have two geographic bases—the location of the inventors and the location of the assignee. For this analysis, Battelle uses the location of the named inventor(s) as the geography of record. Hence, if a bioscience patent is invented by individuals in two states, each state will receive "credit" for the patent; but, at a national level, the patent is counted only once. Similarly, when two or more named inventors are from the same state, the patent is counted only once.

USPTO assigns each patent to a specific numeric major patent "class" as well as supplemental secondary patent classes. By combining relevant patent classes across the wide array of bioscience-related activity, these class designations allow for an aggregation specific to the biosciences. Battelle has grouped these relevant patents into broader patent class groups for this analysis.

Patent data were collected using the Thomson Reuters Delphion patent analysis tool and includes all published patents from January 1, 2005, through June 30, 2008. Table A-2 provides a listing of the patent classes and class groups used in this analysis.

Table A-2. Bioscience-related patents—classes and groups

BIO Patent Class Group	Major Patent Class	Patent Class Name
Agricultural Bioscience	71	Chemistry: fertilizers
Agricultural Bioscience	504	Plant protecting and regulating compositions
Agricultural Bioscience	PLT	Plants
Biochemistry	435	Chemistry: molecular biology and microbiology
Biochemistry	436	Chemistry: analytical and immunological testing
Biochemistry	530	Chemistry: natural resins or derivatives; peptides or proteins; lignins or reaction products
Biochemistry	536	Organic compounds: Carbohydrates and related
Biotechnology	800	Multicellular living organisms and unmodified parts and related processes
Biotechnology	930	Peptide or protein sequence
Drugs & Pharmaceuticals	424	Drug, bio-affecting and body treating compositions
Drugs & Pharmaceuticals	514	Drug, bio-affecting and body treating compositions
Surgical and Medical Instruments	128	Surgery: in vitro devices and respiratory devices
Surgical and Medical Instruments	600	Surgery: diagnostic/therapy testing, techniques, or devices
Surgical and Medical Instruments	601	Surgery: kinesitherapy
Surgical and Medical Instruments	602	Surgery: splint, brace, or bandage
Surgical and Medical Instruments	604	Surgery: blood/fluid-related devices
Surgical and Medical Instruments	606	Surgery: surgical instruments and devices
Surgical and Medical Instruments	607	Surgery: light, thermal, and electrical application
Other Medical Devices and Equipment	351	Optics: eye examining, vision testing and correcting
Other Medical Devices and Equipment	433	Dentistry
Other Medical Devices and Equipment	623	Prosthesis (i.e., artificial body members), parts, or aids and accessories
Other Medical Devices and Equipment	D24	Medical and laboratory equipment
Other Bioscience-Related	Various	Includes patents whose main patent class is not one of the above, but have one of the above as a secondary patent class reference.

Bioscience-Related Occupational Employment

The BLS Occupational Employment Statistics (OES) program produces employment and wage estimates for more than 800 occupations.[11] From these specific occupations, OES data from May 2006 and 2007 were used to construct and calculate occupational employment totals for four bioscience-related occupational groupings: agricultural, food, and nutrition scientists and technicians; biological scientists and technicians; biomedical and biochemical scientists and engineers; and medical and clinical laboratory technicians. Table A-3 lists BLS OES data for 2007 pertaining to bioscience-related occupational employment for Maryland and the benchmark states.

More information on the BLS OES program is available at [http://www.bls.gov/oes/home.htm.](http://www.bls.gov/oes/home.htm)

[11] The OES survey covers all full-time and part-time wage and salary workers in nonfarm industries. Surveys collect data for the payroll period including the 12th day of May. The survey does not cover the self-employed, owners and partners in unincorporated firms, household workers, or unpaid family workers.

Table A-3. Detailed bioscience-related occupational employment, Maryland and benchmark states, 2007

Occupation	California		Pennsylvania		Massachusetts		North Carolina		New Jersey		Maryland	
	2007 Employment	LQ	2007 Employment	LQ	2007 Employment	LQ	2007 Employment	LQ	2007 Employment	LQ	2007 Employment	LQ
Total Employment, All Occupations	**15,202,530**	**1.00**	**5,663,070**	1.00	**3,207,840**	**1.00**	**4,013,460**	**1.00**	**3,980,080**	**1.00**	**2,551,910**	**1.00**
Agricultural and Food Science Technicians	2,860	**1.31**	520	0.64	290	0.63	800	**1.39**	300	0.53	400	1.09
Animal Scientists	-	-		-		-		-	190	**1.52**	90	1.13
Soil and Plant Scientists	1,320	1.14	170	0.39	50	0.20	470	**1.53**	110	0.36	160	0.82
Biological Scientists, All Other	3,280	1.07	280	0.25	820	**1.27**	1,240	**1.53**	700	0.87	2,760	**5.37**
Biological Technicians	9,510	**1.22**	3,100	1.06	6,240	**3.78**	3,410	**1.65**	2,600	**1.27**	2,740	**2.09**
Epidemiologists	440	0.98	120	0.72	150	**1.59**	130	1.10	40	0.34	150	**1.99**
Medical Scientists, Except Epidemiologists	18,090	**1.83**	7,360	**2.00**	5,700	**2.73**	2,700	1.03	3,540	**1.37**	2,640	**1.59**
Microbiologists	1,810	1.09	480	0.78	950	**2.72**	260	0.60	890	**2.06**	1,350	**4.86**
Biochemists and Biophysicists	3,520	**1.60**	1,870	**2.28**	2,790	**6.00**	850	**1.46**	1,530	**2.65**	280	0.76
Biomedical Engineers	3,160	**1.81**	1,100	**1.69**	1,420	**3.86**	580	**1.26**	430	0.94	500	**1.71**
Dental Laboratory Technicians	4,910	0.97	1,790	0.95	710	0.67	1,180	0.89	1,060	0.80	590	0.70
Medical and Clinical Laboratory Technicians	12,650	0.77	9,380	**1.53**	7,560	**2.17**	4,800	1.10	3,020	0.70	2,570	0.93
Medical and Clinical Laboratory Technologists	13,020	0.70	8,530	**1.24**	7,470	**1.92**	5,120	1.05	4,820	1.00	3,280	1.06
Medical Appliance Technicians	2,060	**1.53**	1,290	**2.57**	210	0.74	330	0.93	410	1.16	160	0.71
Ophthalmic Laboratory Technicians	2,220	0.63	1,610	**1.24**	550	0.75	240	0.26	720	0.79	560	0.95
Total Biosciences	**78,850**	**1.04**	**37,600**	1.34	**34,910**	2.19	**22,110**	**1.11**	**20,360**	**1.03**	**18,230**	1.44

Source: Battelle analysis of BLS OES data, 2007. Location quotients (LQs) highlighted in red indicate a specialized concentration of state jobs.